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Mr. Terence Cuneo has been commissioned by Vickers Limited to produce a series of drawings giving his impressions of the immense resources and production capacities of the Vickers Group. Mr. Cuneo's original pencil sketch and notes for his subject, made on the spot and reproduced here, convey in a particularly vivid manner the size and capabilities of the Nineteen shops.

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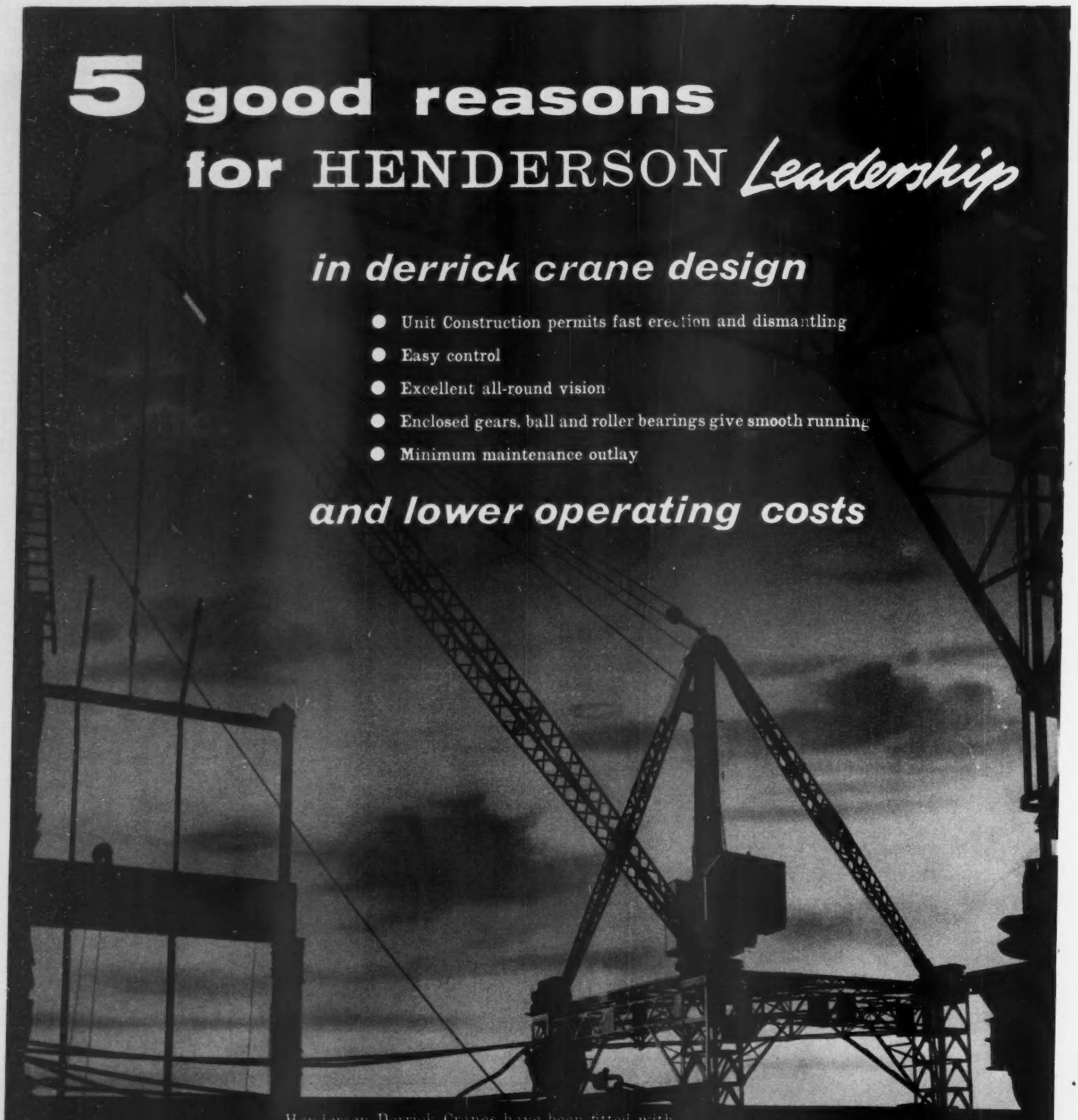

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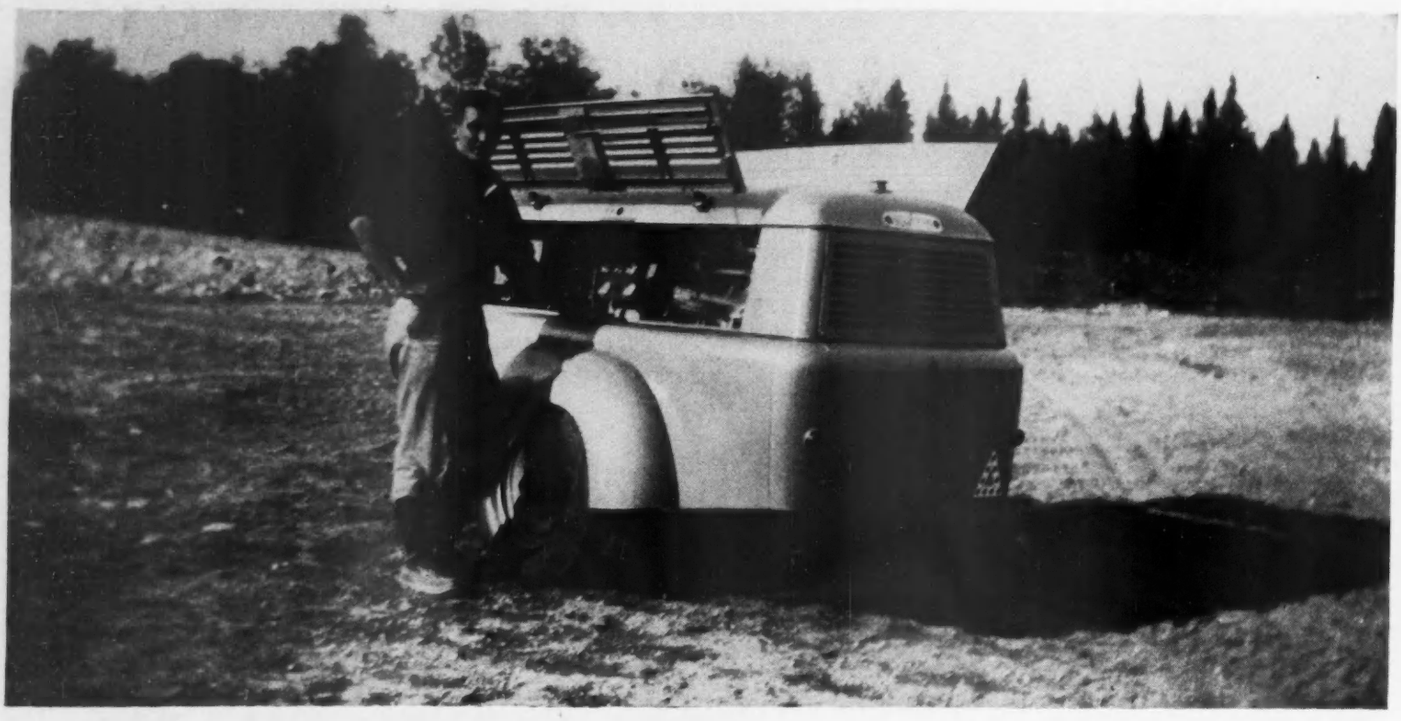

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15 April 1960

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Founded in 1866

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Cover Picture

A small reactor in terms of output, the United Kingdom Atomic Energy Authority's Advanced Gas-cooled Reactor, now building at Windscale, will have an electrical capacity of 28 MW, but is in fact a prototype for the second generation of large nuclear power stations. *(UKAEA photograph)*

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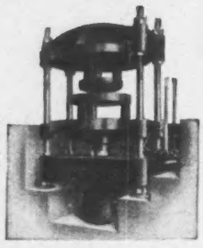

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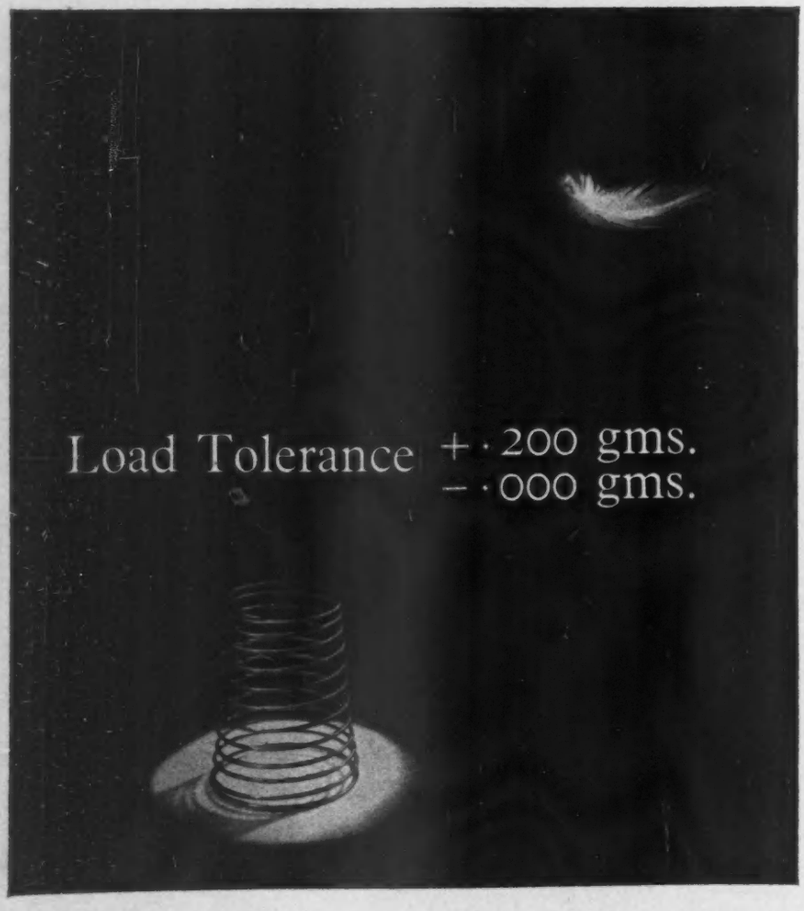

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MOTOR DRIVEN ANGLE CROPPING MACHINE for sale. All steel construction. Crops angle at 90 deg., 7 in. by 7 in. by ½ in.; also on the mitre. Motor drive 400/440/3/50.—F. J. EDWARDS LIMITED, 359, EUSTON ROAD, LONDON, N.W.1, or 41, WATER STREET, BIRMINGHAM, 3. B 797

NEW BESCO 10 FT. BY ¼ IN. PRESS BRAKE for sale. Immediate delivery. All steel construction. Pressure 80 tons. Motor driven. Between side frames 97½ in.—F. J. EDWARDS LIMITED, 359, EUSTON ROAD, LONDON, N.W.1, or 41, WATER STREET, BIRMINGHAM, 3. B 798

PATENTS

THE PROPRIETOR OF BRITISH PATENT NO. 767200 for "IMPROVEMENTS IN OR RELATING TO COMPRESSION IGNITION ENGINES," desires to enter into negotiations with a firm or firms for the sale of the patent or for the grant of licences thereunder. Further particulars may be obtained from MARKS & CLERK, 57 and 58, LINCOLN'S INN FIELDS, LONDON, W.C.2. B 808

'Engineering' Appointments Section

ADVERTISEMENT RATES

CLASSIFICATIONS: Public Appointments, Appointments Open, Appointments Wanted.

TYPES OF ADVERTISEMENTS:

(a) "Appointments Illustrated" and illustrated careers advertisements: photographs or drawings may be used in conjunction with type matter.

Rates per page: (12 in. by 9 in.)	£100
half page	£54
quarter page	£29

(b) Semi-display: type matter, with or without surrounding rule, name block or symbol.

Rates: per page (12 in. by 9 in.)	£100
half page	£54
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single column inch	£2 14s.

(c Single column "run-on" advertisements: approximately 6 words to the line, 12 lines to the inch.

Rate per line	4s. 6d.
(Minimum charge 18s.	

SERIES DISCOUNTS: 5 per cent. on 6 insertions; 10 per cent. on 13; 15 per cent. on 26.

BOX NUMBER: 2s.

COPY DATE: First post Monday.

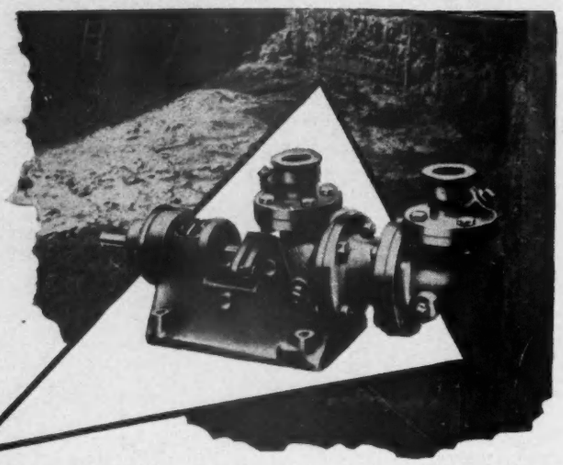
BLOCKS: To be mounted ready for printing. Screen 100.

ORDERS TO: "Engineering" 36, Bedford Street, London, W.C.2. (Telephone TEMple Bar 3663)

For 'Engineering' Appointments Section, turn to the centre of editorial section

SLUDGE
Disposal

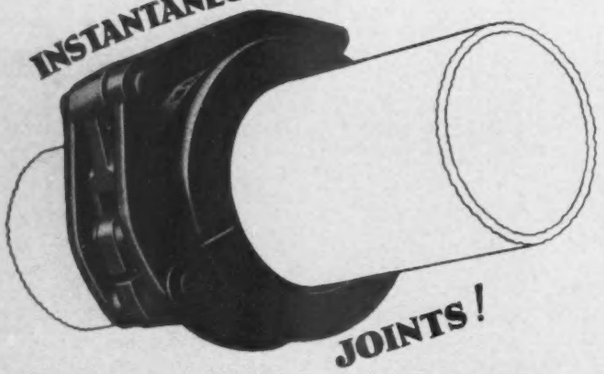
Residue sludge or slurry often creates a major problem of disposal. It may be viscous or carry solids in suspension and it is frequently corrosive or abrasive. The Mono Pump has shown a great ability at handling such mixtures and has saved considerable manpower, time and money by pumping sludge effluent direct from pits and settling tanks to transportation for disposal or to plants or by-product recovery. The Mono Pump is self-priming, positive in action and has a high suction power. It is simple and needs the minimum attention.



The MONO pump

MONO PUMPS LIMITED
MONO HOUSE · SEKFORDE STREET · LONDON, E.C.1
Telephone: CLErkenwell 8911
Telegrams: Monopumps 'Phone London
and at Belfast, Birmingham, Capetown, Dublin, Durban, Glasgow, Johannesburg, Manchester, Melbourne, Newcastle, Wakefield.

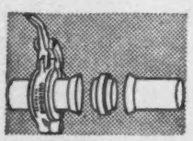
INSTANTANEOUS JOINTS!



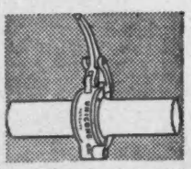
A perfect seal in a matter of seconds

For temporary pipe lines 'Unicone' instantaneous joints are recommended. Comprising two parts only, they fasten with a "snap" ensuring a perfect seal in a matter of seconds.

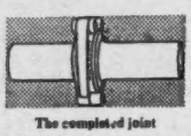
For permanent or semi-permanent pipe lines, 'Unicone' bolted type joints are usually employed and can be assembled far more quickly than any other flexible joint giving positive anchorage.



Rubber gasket in position and joint ready to pull over



Pipe ends joined ready for locking



The completed joint

'UNICONE' REG'D.

Flexible Joints for Pipelines

Leakproof. safe. reliable

THE UNICONE CO., LIMITED
RUTHERGLEN, GLASGOW, SCOTLAND

FURNACES

Gas and Oil Fired Industrial Furnaces
Refractory Installations (New and Repair)
Redesigning and Rebuilding of existing Furnaces

MANCHESTER FURNACES LTD
GLOBE WORKS, ASHTON NEW RD.
MANCHESTER, 11
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For keeping this to this

you need a KOLOK

POSITIVE LOCK WASHER

Nuts and bolts stay firmly in place, are unaffected by vibration, when a KOLOK Positive Lock washer is fitted between them. Available in all sizes.

POSITIVE LOCK WASHER CO. LTD.
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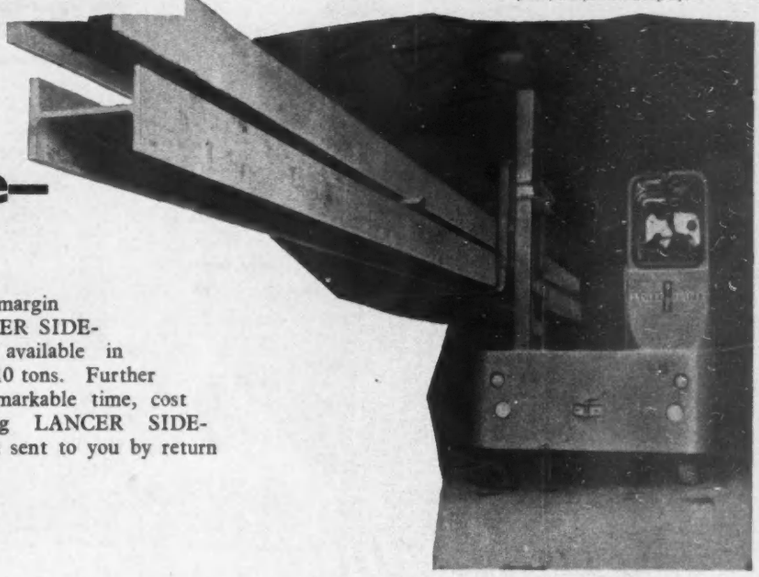
You've got the problem—

NARROW GANGWAYS — BULKY LOADS — COSTLY STORAGE SPACE

We've got the machine—

An All-British Product Manufactured by a completely Independent Company.



. . . and it is the most economical form of mechanised handling you can obtain today.

The LANCER range of SIDELOADERS operates efficiently in gangways only 7ft. 6in. wide, carrying long or palleted loads in complete safety on the 14ft. deck. LANCER SIDELOADERS are extremely fast in operation, easy to drive and built to operate with a really adequate margin of safety. LANCER SIDE-LOADERS are available in capacities of 3 to 10 tons. Further details of the remarkable time, cost and space saving LANCER SIDE-LOADERS will be sent to you by return of post.

LANCER SIDE LOADER

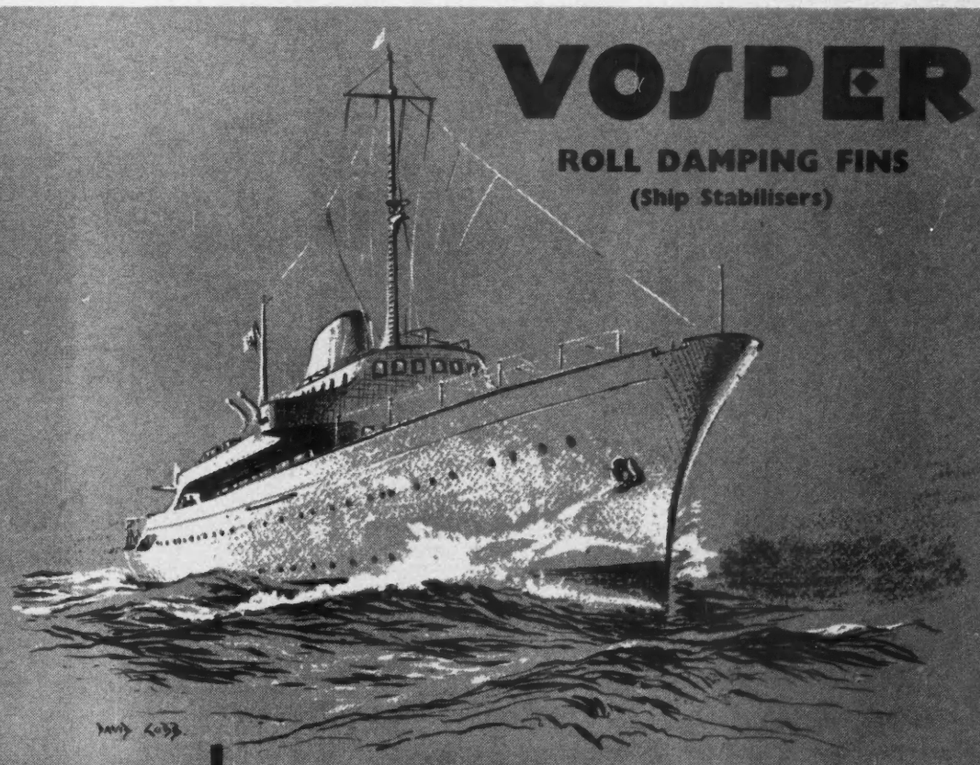
Sideloader is the Trade Mark of Lancers Machinery Ltd.

LANCERS MACHINERY LTD.
41 KNIGHTSBRIDGE, LONDON, S.W.1.
TELE: BELgravia 6374.

See us on Stand M.4, Mechanical Handling Exhibition Earls Court 3rd - 13th May

VOSPER

ROLL DAMPING FINS
(Ship Stabilisers)



325 ft. Yacht Fitted with Vosper Roll Damping Fins in the Mediterranean during 1959.

Our equipment has been fitted to many ships varying in size from 58 feet in length (24 tons displacement) to 325 feet (2,800 tons displacement) with a transforming effect on their comfort, safety and seakeeping qualities.

VOSPER LIMITED **PORTSMOUTH ENGLAND**

announcing the latest

FIELDING

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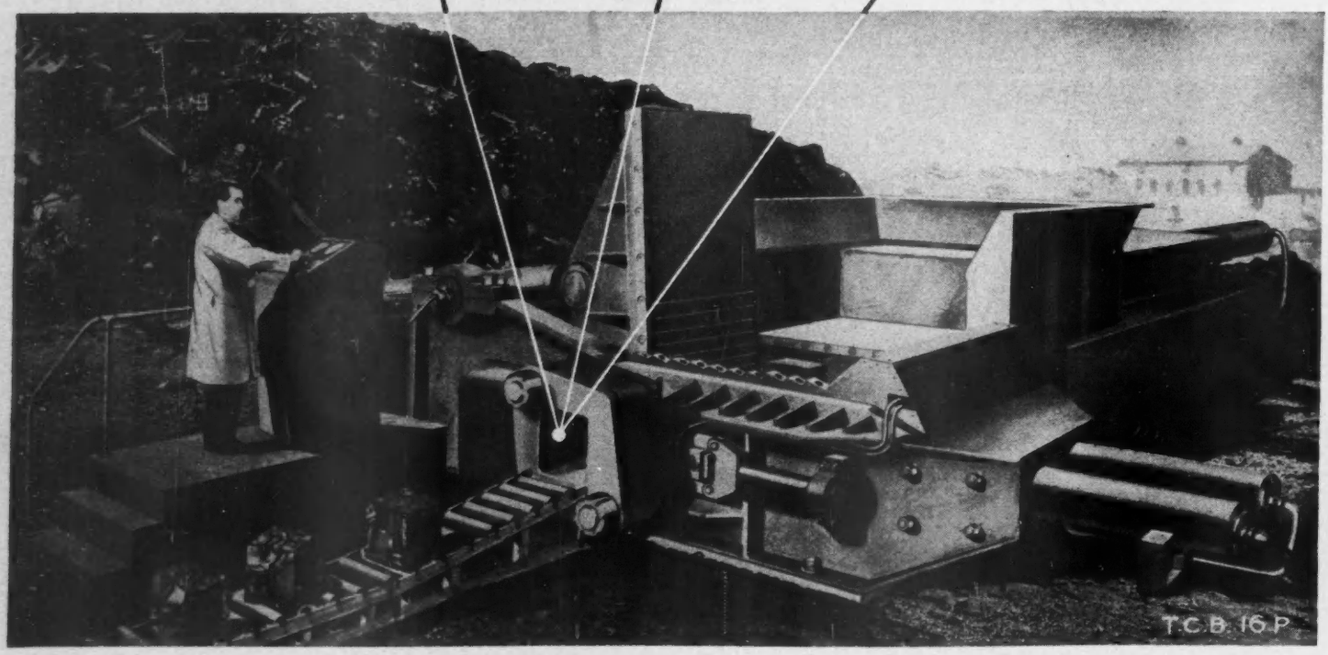
High Speed

CUBE BALERS



'FIELDING' Cube Balers—with pre-compressing unit—are designed to handle large volumes of general scrap and are especially suitable for the larger scrap yard and factory. Fully self-contained units, they are easily sited on simple block foundations. Press motions may be carried out under Auto-continuous, Cyclic or Hand Control to suit the customer's individual requirements.

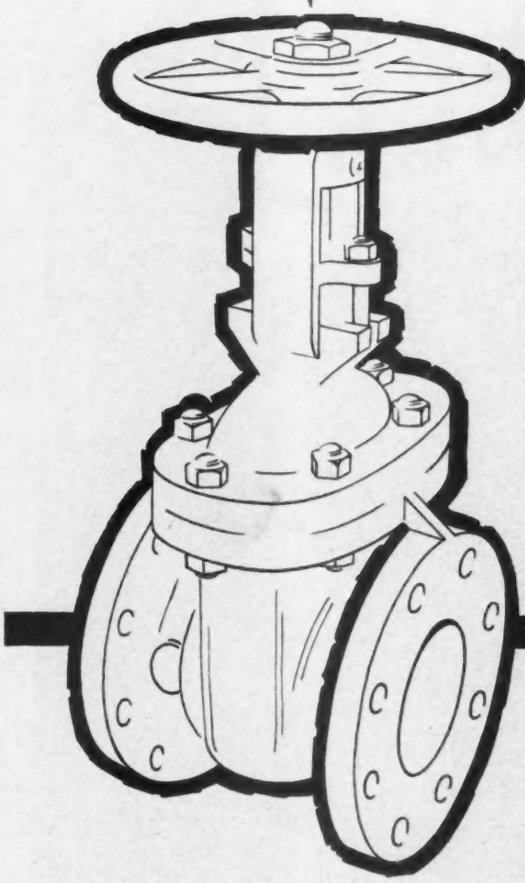
FIELDING F&P PLATT MEMBER OF THE HEENAN GROUP

Write now for further information and details of these latest FIELDING PRESSES

FIELDING & PLATT LTD · ENGINEERS GLOUCESTER

K/FP. 29

An Announcement



Remploy Ltd offer the services of their valve reclamation unit

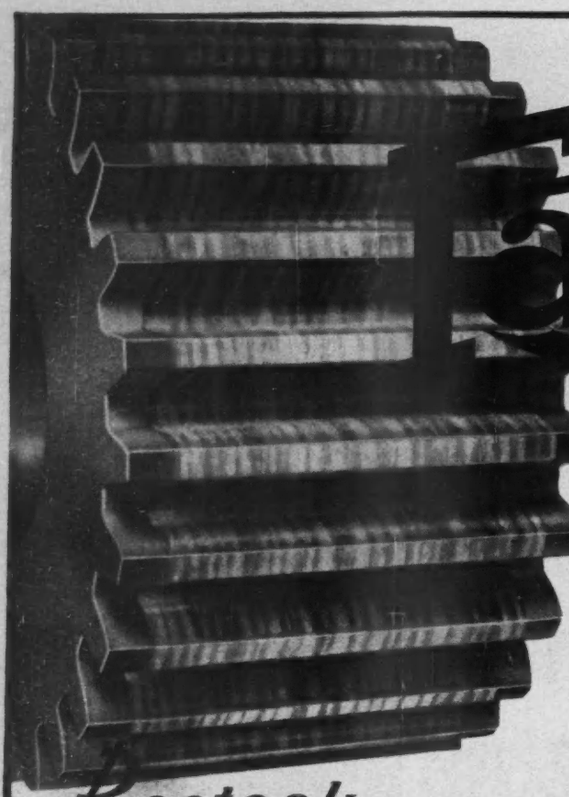
Following the success of the initial plant in South Wales, we have established a larger unit in the Manchester area.

This service, which is already used by all the major Oil Companies includes reconditioning of GLOBE VALVES as well as PARALLEL AND WEDGE TYPE SCREWED GATE VALVES as supplied for the Oil Refinery and Petrochemical Industries.

Remploy

For details of the scheme, apply to:—

Engineering Group Controller, Remploy Limited, Oxgate Lane, Cricklewood, London, N.W.2.



Fabroil

Silent GEARS

To ensure minimum friction and noiseless running, the choice of material for non-metallic gears is of great importance; such gears must have hard, smooth-wearing surfaces, and must possess great strength, elasticity, and shock-absorbing powers. Fabroil gears possess these qualities to a pre-eminent degree; and are far superior to gears of raw-hide, paper and other materials.

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Telephone STALYBRIDGE 3232/3
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by

Caston Barber

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Producing Hemispherical ends and other hydraulic pressings of up to 3 feet in diameter, Caston Barber have a wide range of existing tools, a list of which will gladly be sent on request. Dished and Flanged cylinder ends, with or without inspection openings, are also manufactured to order.

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Caston Barber produce rings from a wide range of flat and angled sections of mild or stainless steel. Flanged rings and washers are supplied to meet all specifications and in many cases the rings are flash butt welded.
Caston Barber have the equipment and the experience to meet your requirements.

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hot hot hot hot

but never bothered

Where seals and gaskets are required to remain fully efficient over long periods at exceptionally high temperatures, Silastomer* silicone rubber supplies the complete answer.

Silastomer remains fully serviceable at temperatures up to 250°C, where organic rubbers char and melt, and certain grades are available for intermittent use at temperatures as high as 300°C. Nor do extremes of cold affect its properties: Silastomer is still serviceable at —70°C.

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*Silastomer is the registered trade name of a comprehensive range of silicone rubbers manufactured and marketed by

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first in British Silicones

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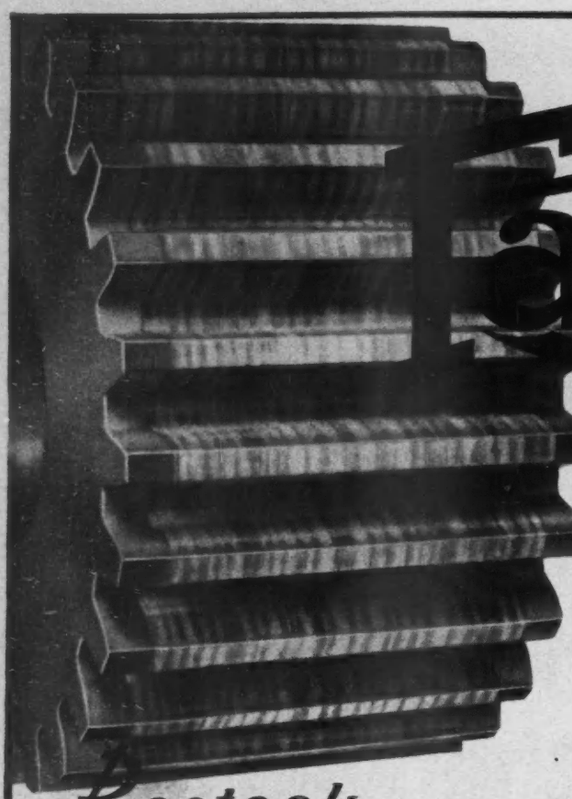
Area Sales Offices: Birmingham, Glasgow, Leeds, London, Manchester
Agents in many countries

MSR1b



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***first** in British Silicones*

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Architects and Planning Engineers who are contemplating the incorporation of overhead cranes in new buildings or extensions are invited to write for our Table of Clearances, Weights, Wheel Loads, etc., for Standard E.O.T. Cranes. Advice on all lifting problems gladly supplied by our technical staff without obligation.

John Smith Cranes give the slow speed control and fine setting vital in all foundry work. This feature can be included equally well on both A.C. and D.C. operated cranes

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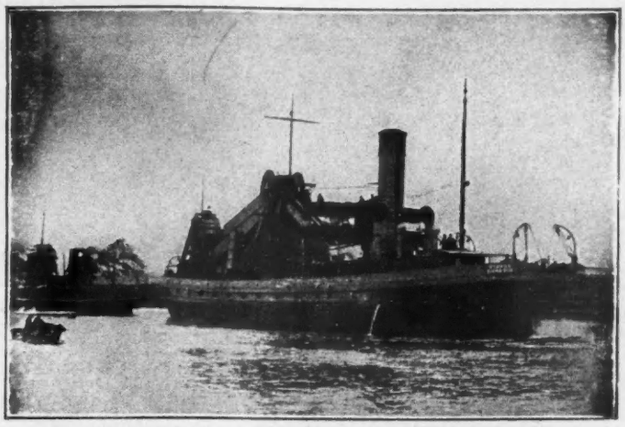
Telephone: Keighley 5311 (4 lines) Telegrams: Cranes, Keighley

London Office: Buckingham House, 19/21 Palace St, Westminster, London SW1. Southern Counties Office: Brettenham House, Lancaster Place, London WC2



OIL-BURNING TWIN-SCREW HOPPER DREDGER "OTAKOU"
constructed for the
OTAGO HARBOUR BOARD, DUNEDIN, NEW ZEALAND
Dimensions: 258 ft. × 20 ft. Hopper capacity 2,000 tons
Speed loaded: 9½ knots Dredging capacity per hour: 1,000 tons

DREDGING PLANT

TO THE LARGEST DIMENSIONS AND CAPABILITIES

PATENT CUTTER SUCTION DREDGERS, PATENT DIPPER DREDGERS, BUCKET HOPPER DREDGERS, SUCTION HOPPER DREDGERS, HOPPER BARGES, PIPE LINES FLOATING CRANES, etc.

NEW BUCKETS, LINKS, PINS, GEARING, etc., supplied for existing Dredgers

FLEMING & FERGUSON, Ltd.,

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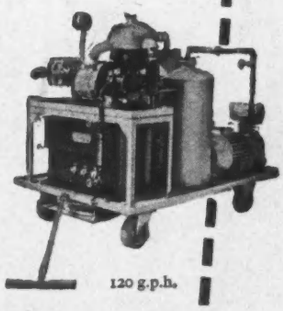
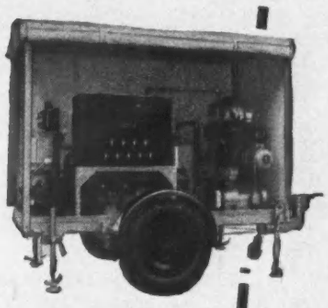
HIGH VACUUM SEPARATORS for INSULATING OIL TREATMENT

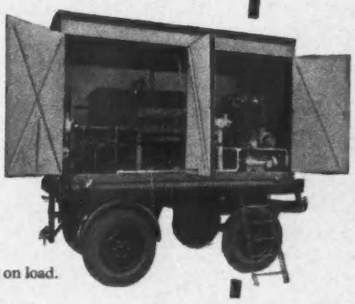
A wide range of Stationary, Portable and Roadworthy Portable Units with capacities from 10—1200 g.p.h.



120 g.p.h.



800 g.p.h.



1200 g.p.h.

Specially designed high-efficiency equipments that ensure:—

Maximum di-electric strengths, well above B.S.S. requirements for new oils, which are retained for longer periods.

Maximum extraction of free and dissolved moisture, air and solids, including colloidal carbon.

No back pressures or fall-off in throughput capacity.

Excessive quantities of water, sludge or solids which may be formed under abnormal conditions can be efficiently separated.

Minimum heating of oil under high vacuum, low running costs—no filter aids— simple and reliable operation.

These De Laval equipments are now widely employed for:—

1 De-hydration and de-aeration of new oil when filling new transformers at site.
2 Drying out cores and windings of:—
(a) new transformers at site before they are put on load. (b) existing transformers whilst on load.
3 Improving the breakdown strength of oil in transformers on load.
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Designers and Builders of Steam, Diesel and Diesel-electric and Battery Locomotives for all purposes. Flame Proof Diesel and Battery Locos for underground working.

HUDSWELL, CLARKE & COMPANY LIMITED

Railway Foundry, Leeds

LONDON OFFICE:
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Victoria Street, S.W.1
TELEPHONE: Victoria 5786

The perfect joint compound for all screwed pipe joints

also for: Vee-Reg Valves
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and all pipe-line accessories
Write to:—

The British Steam Specialties LIMITED
Fleet Street, Leicester
— and Depots —

✳ The STANDARD RANGE of Nyloc Self-Locking Nuts has been extended in ¼″ stages from 2¼″ to 4″.

✳ Simmonds are the first to produce British and Unified nuts up to 4″ nominal diameter as standard stocking items.

✳ ALL sizes of Nyloc Self-Locking Nuts are obtainable direct from stock,

* *All times shown are based on "The Handbook of Standard Time Data for Machine Shops" by Haddon & Genger, published by Thames & Hudson Limited, London.*

SIMMONDS AEROCESSORIES LIMITED

TREFOREST, PONTYPRIDD, GLAMORGAN

A MEMBER OF THE FIRTH CLEVELAND GROUP

Branches: London, Birmingham, Manchester, Glasgow, Stockholm, Copenhagen, Ballarat, Sydney, Johannesburg, Amsterdam. Milan, New York, Mannheim and Brussels.

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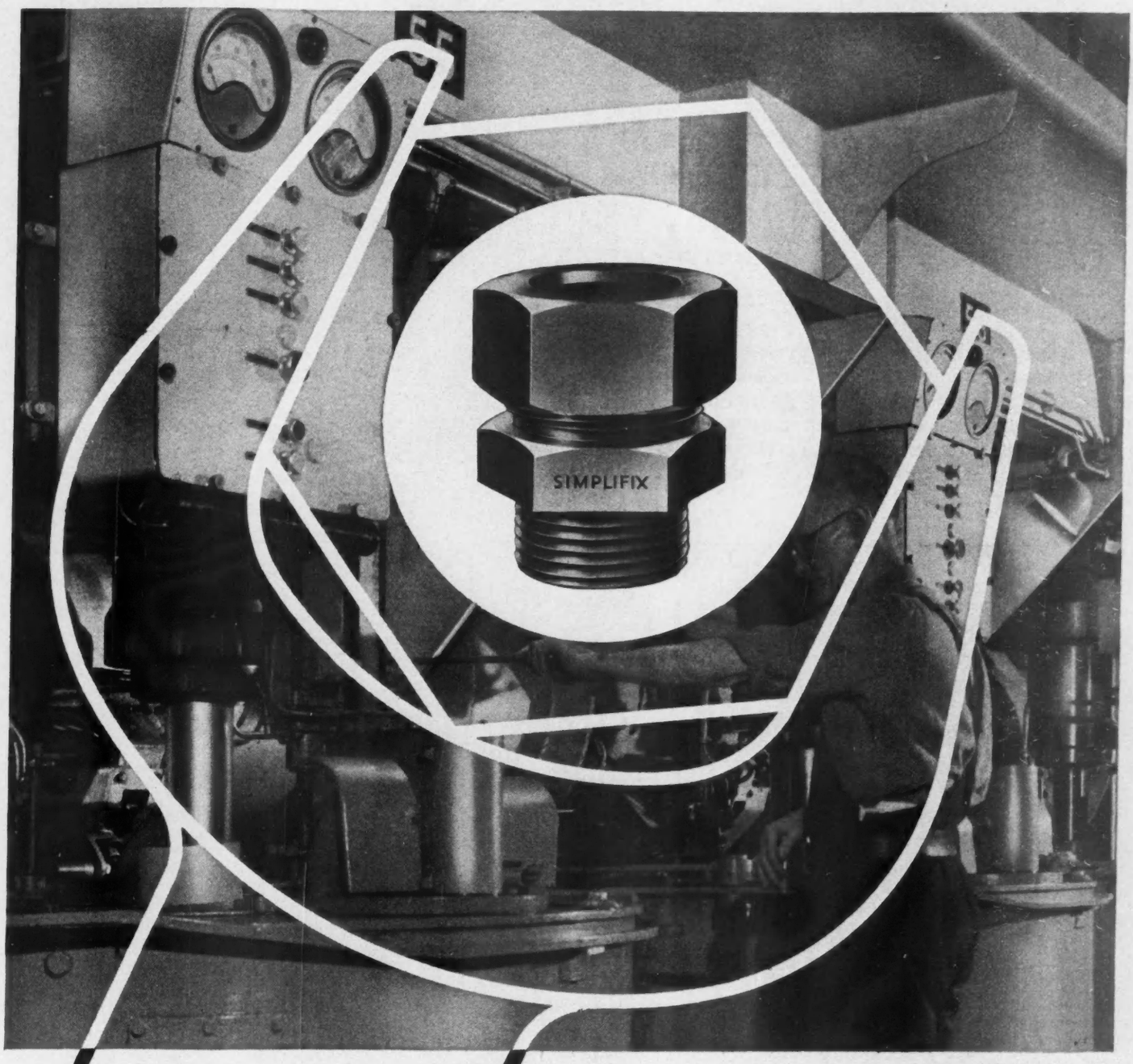

Engineers prefer SIMPLIFIX the foolproof coupling

Simplifix—the sure and simple compression coupling for copper pipe. Perfect joints with almost all kinds of tubing, including those with very thin walls. No work to do on the pipe. Simply tighten the nut—the anti-friction washer prevents the pipe twisting. Manufactured since 1930, still the best. Millions in use. Made in sizes to suit tubing from $\frac{1}{8}$" to 2" O.D., in a wide range of interchangeable standard fittings. Non-standard fittings also made to order. Let us send you the Simplifix catalogue.

The illustration shows centrifugal machines at the Plaistow Wharf Sugar Refinery of Tate and Lyle Ltd., where large numbers of Simplifix couplings are used.

SIMPLIFIX

SIMPLIFIX COUPLINGS LTD · HARGRAVE ROAD
MAIDENHEAD · BERKS · TEL: MAIDENHEAD 5100
A member of the ALENCO Group of Companies

Time and time again

TIME PAST

Vokes Genspring hangers were introduced to provide constant support for high temperature pipework over a wide range of vertical movement. One of the applications for which they were specified was the support of pipework at the then revolutionary nuclear power stations at Calder Hall and Chapel Cross.

TIME PRESENT

Such was their success that we are now privileged to supply suspension equipment to the five members of the Nuclear Consortia for the five latest Nuclear Power Stations. A new Genspring capable of supporting 97,800 lb. with a 12″ vertical travel has been built mainly for use in Nuclear Power applications.

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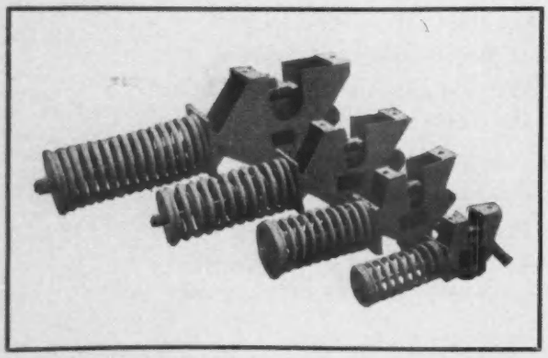
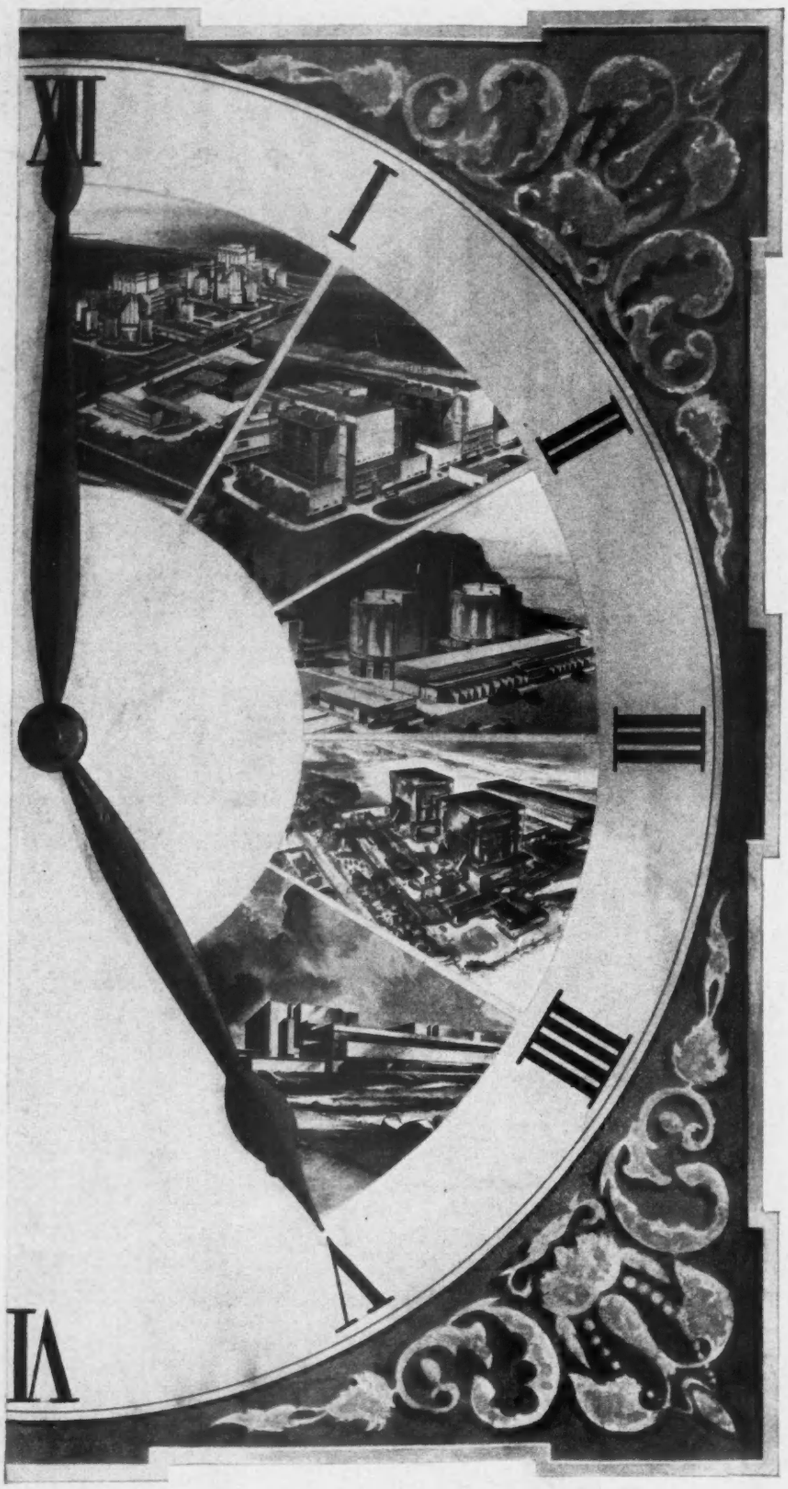
Vokes Genspring have thus built up a unique fund of specialised knowledge which will prove invaluable in overcoming new pipe support problems which the power stations of the future will almost certainly present.

Illustrated below are the M1 to M4 Constant Supports covering loads from 315 lb. to 22,500 lb. and travels from 1.5″ to 12″. The latest addition to the range is Type M7 for loads up to 97,800 lb.





The illustrations above are artists' impressions of the Nuclear Power Stations at Berkeley (A.E.I.—John Thompson Nuclear Energy Co. Ltd.); Bradwell (The Nuclear Power Plant Company Ltd.); Hunterston (G.E.C.–Simon Carves Group); Hinkley Point (English Electric, Babcock & Wilcox, Taylor Woodrow Atomic Power Group) and Trawsfynydd (Atomic Power Constructions Ltd.)

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VG47

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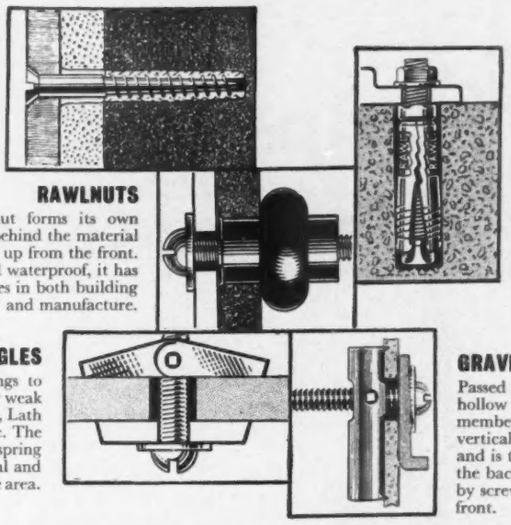
RAWLPLUGS
The famous Rawlplug makes firm screw fixings in masonry in a mere fraction of the time taken by any other method. For all screw sizes up to ¾ in. diam. coach screws.

RAWLNUTS
The amazing Rawlnut forms its own 'rivet head' behind the material when screwed up from the front. Shakeproof and waterproof, it has many valuable uses in both building and manufacture.

SPRING TOGGLES
For making firm fixings to such thin and structurally weak materials as plasterboard, Lath and Plaster, ceilings, etc. The wings of the device spring apart behind the material and spread the load over a wide area.



RAWLBOLTS
For light or heavy bolting jobs. A dry fixing of enormous strength—no cold chiselling, no waiting for cement to harden. In all bolt diameters up to 1 in.

GRAVITY TOGGLES
Passed through a hole in hollow material, the long member falls into a vertical position by gravity, and is then drawn against the back of the material by screwing from the front.

RAWLPLUG

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However tough or awkward the material into which you want to fix, or difficult the problem, there will be among the 21 TYPES OF RAWLPLUG FIXING DEVICES, the right answer. Speed and simplicity of application, reliability and complete security, coupled with the RIGHT solution to a problem, are the foundations of the RAWLPLUG FIXING TECHNIQUES.

THERE ARE 21 DIFFERENT TYPES

B 685

and an all-inclusive range of high performance hole-boring tools, hand or power.

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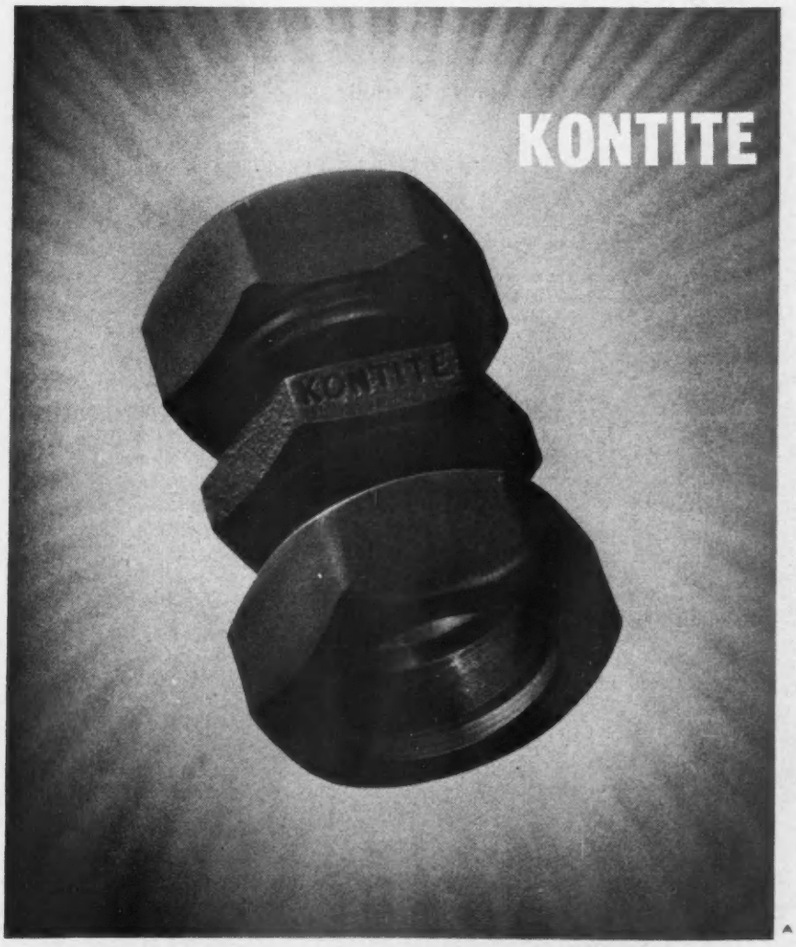

THE PERFECT PIPE FITTING

Kontite compression fittings can solve your pipeline problems at the turn of a spanner. Designed to make coupling easier, better and cheaper, they are available to suit all pipe sizes up to 6″ bore.

There are over 22,000 types and sizes of Kontite fittings, produced in gunmetal to resist corrosion.

Kay's delivery service is as outstanding as their fittings – most items can be sent by return.

Fully illustrated catalogue of Kontite fittings will be supplied on request.

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Time and time again

TIME PAST

Vokes Genspring hangers were introduced to provide constant support for high temperature pipework over a wide range of vertical movement. One of the applications for which they were specified was the support of pipework at the then revolutionary nuclear power stations at Calder Hall and Chapel Cross.

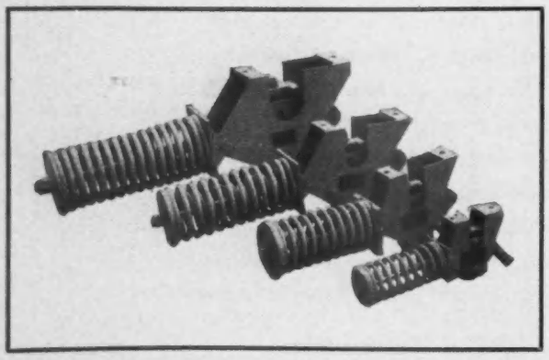
TIME PRESENT

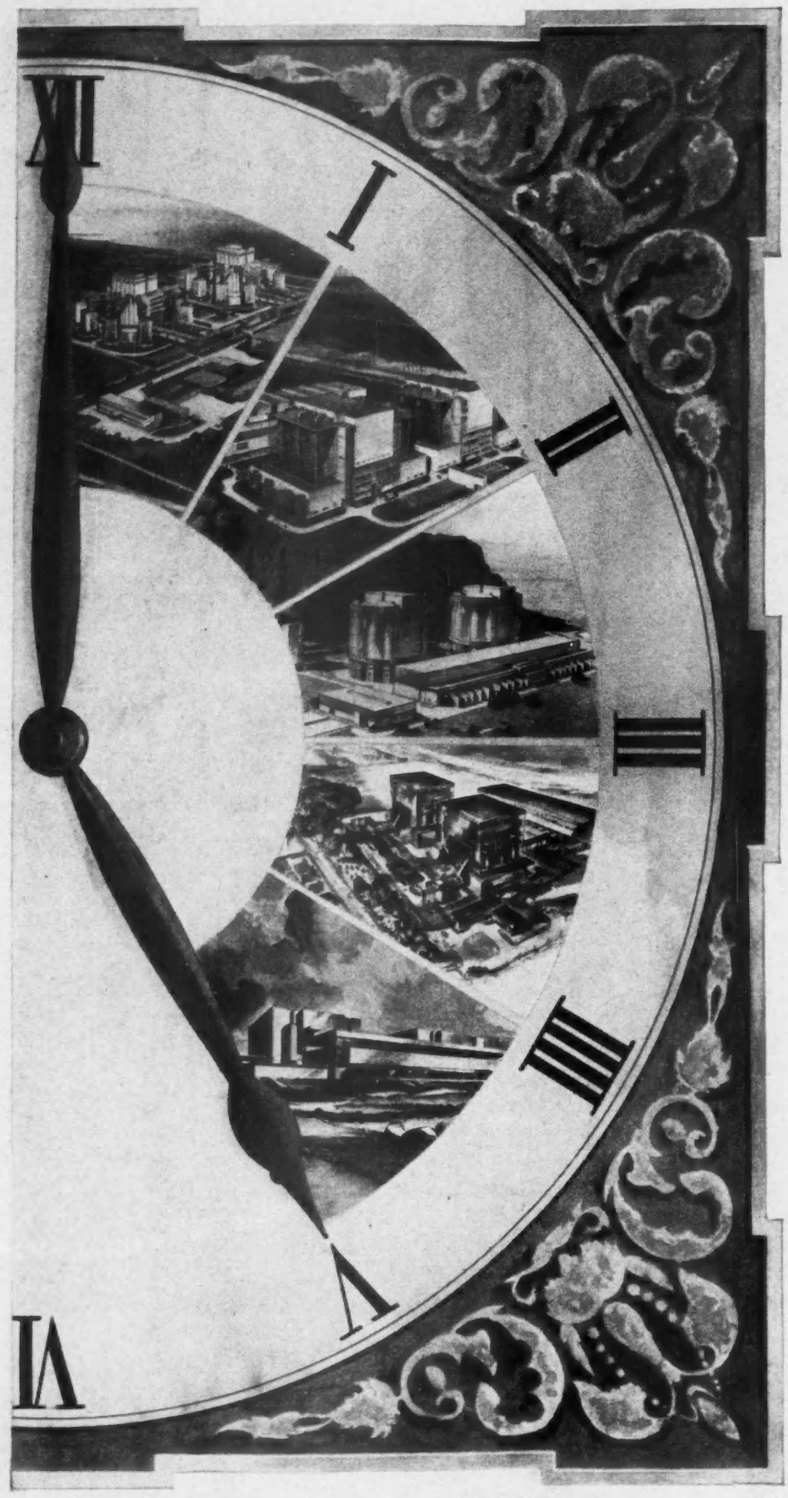
Such was their success that we are now privileged to supply suspension equipment to the five members of the Nuclear Consortia for the five latest Nuclear Power Stations. A new Genspring capable of supporting 97,800 lb. with a 12″ vertical travel has been built mainly for use in Nuclear Power applications.

TIME FUTURE

Vokes Genspring have thus built up a unique fund of specialised knowledge which will prove invaluable in overcoming new pipe support problems which the power stations of the future will almost certainly present.

Illustrated below are the M1 to M4 Constant Supports covering loads from 315 lb. to 22,500 lb. and travels from 1.5″ to 12″. The latest addition to the range is Type M7 for loads up to 97,800 lb.





The illustrations above are artists' impressions of the Nuclear Power Stations at Berkeley (A.E.I.—John Thompson Nuclear Energy Co. Ltd.); Bradwell (The Nuclear Power Plant Company Ltd.); Hunterston (G.E.C.–Simon Carves Group); Hinkley Point (English Electric, Babcock & Wilcox, Taylor Woodrow Atomic Power Group) and Trawsfynydd (Atomic Power Constructions Ltd.)

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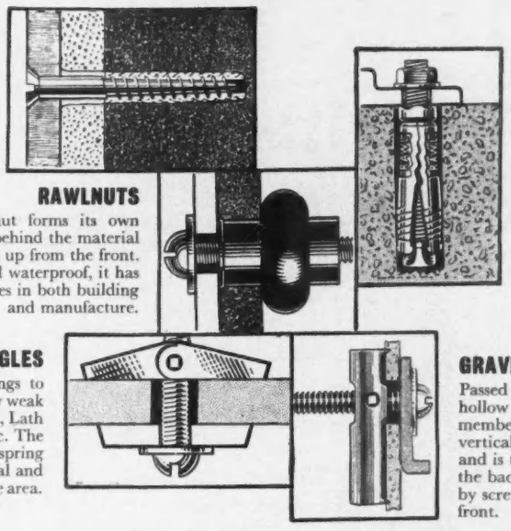
RAWLPLUGS
The famous Rawlplug makes firm screw fixings in masonry in a mere fraction of the time taken by any other method. For all screw sizes up to ⅜ in. diam. coach screws.

RAWLNUTS
The amazing Rawlnut forms its own 'rivet head' behind the material when screwed up from the front. Shakeproof and waterproof, it has many valuable uses in both building and manufacture.

SPRING TOGGLES
For making firm fixings to such thin and structurally weak materials as plasterboard, Lath and Plaster, ceilings, etc. The wings of the device spring apart behind the material and spread the load over a wide area.



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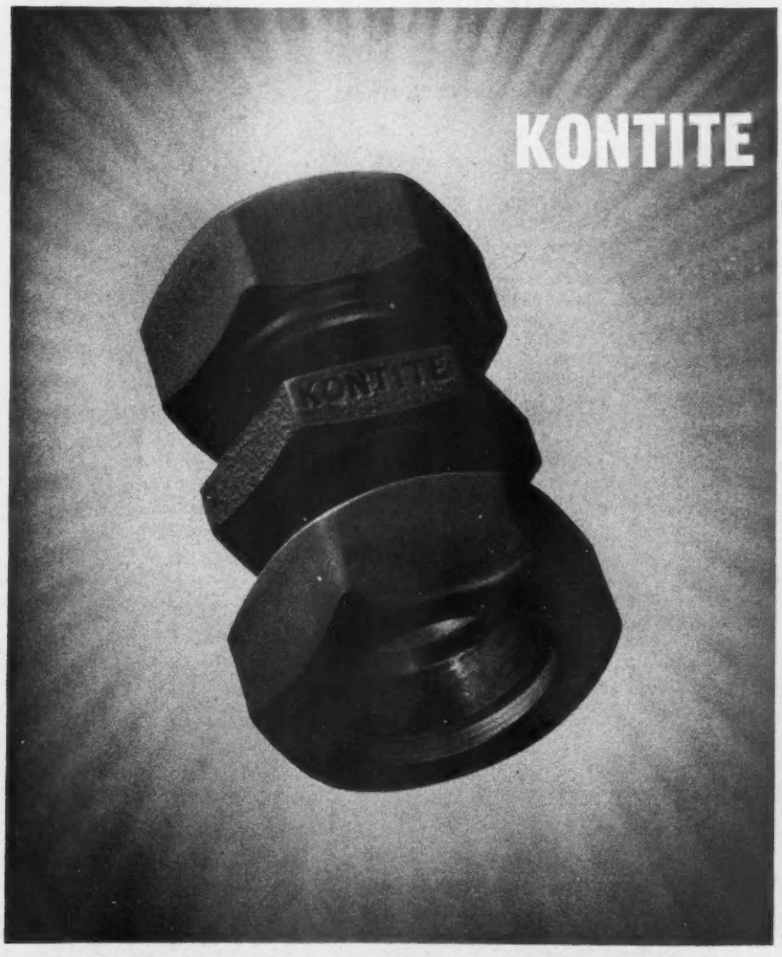

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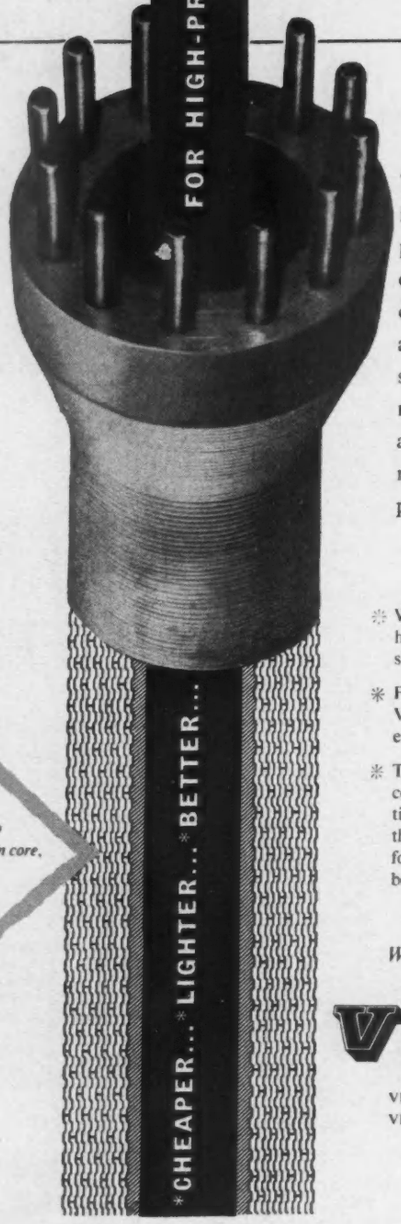
Strip-wound construction?

FOR HIGH-PRESSURE VESSELS



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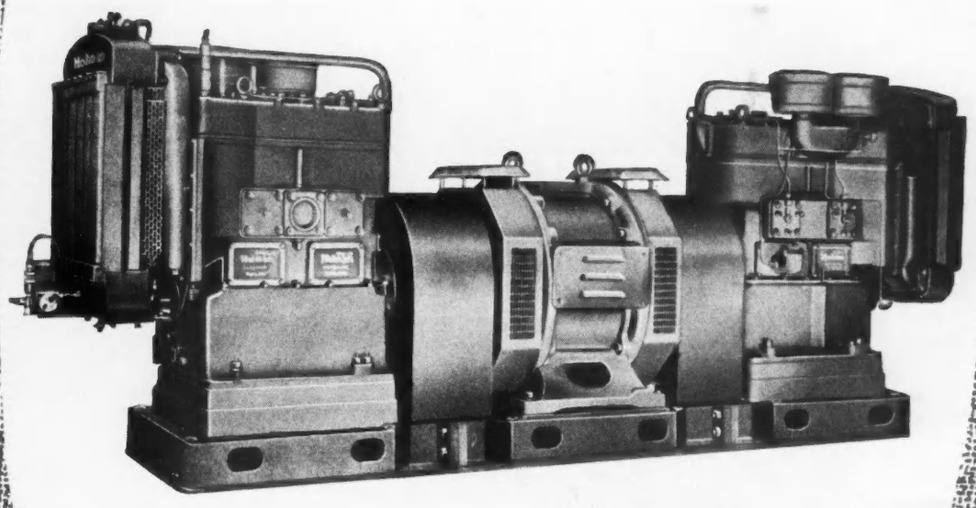

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The Holman Duplex Stationary Compressor . . .

Ideal for in-bye use

Holman design, Holman strength, Holman *efficiency*—you get all these in this new stationary compressor arrangement. And you will find something more—the Duplex set allows almost vibrationless running. Made in two versions, the Duplex features a centre-mounted electric motor (156 or 230 b.h.p.) and twin T60R or T36R compressors. The two models give respectively 1050 or 610 cubic feet a minute at 100 p.s.i. with a maximum of up to 150 p.s.i. The compressor units used are of the well-known Holman two-stage, reciprocating type, with closed-circuit cooling and pressure-oiled bearings.

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The A.E.C. "Dumptruk" gives an unrivalled combination of capacity, economy, power and output. With a payload of up to 30,000 lbs., extra-quick turn-round, and outstanding economy of operation, the A.E.C. "Dumptruk" gives the cheapest cost per yard moved.

1 FULLY ARTICULATED BOGIE
2 Fully constant-mesh 5-speed gearbox
3 UNFAILING POWER
4 RAPID TURN-ROUND
5 Pressed channel section frame
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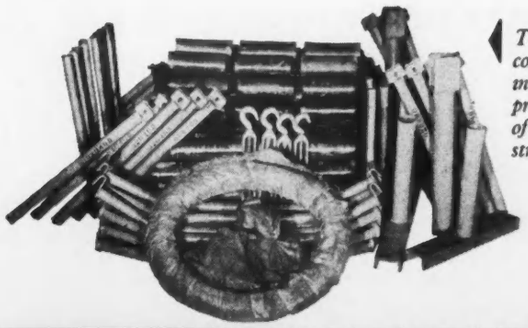
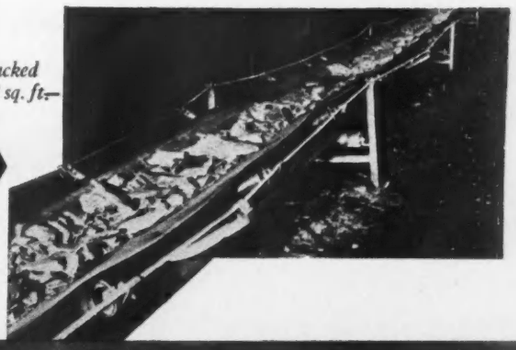
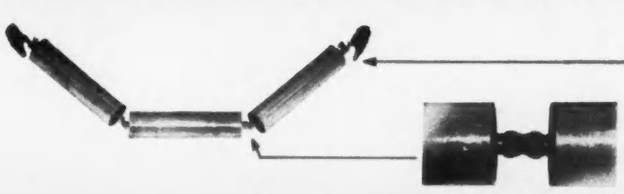


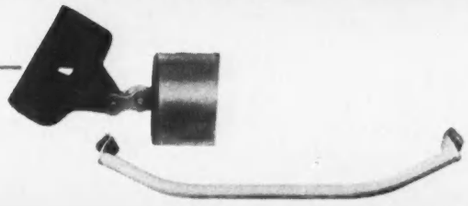
This group of components—stacked in an area of 28 sq. ft.—produce 200 ft. of this conveyor structure . . . .



DISTINGTON-GOODMAN ROPE BELT CONVEYOR STRUCTURE patented



swivel links are fitted at each end of an idler shaft

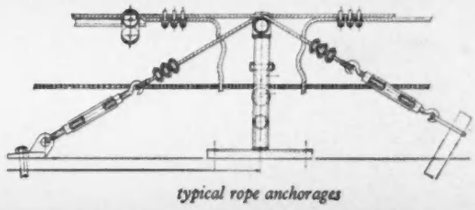


stretchers are used at intervals between stands

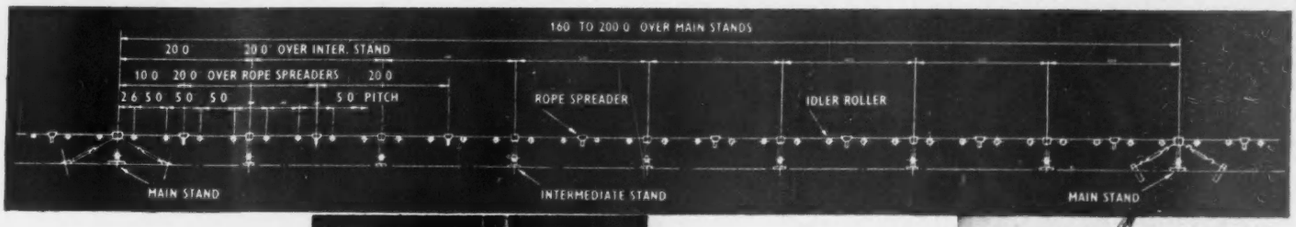
RESILIENT

intermediate supporting stand

main supporting stand



typical rope anchorages



Installation, extension and contraction of Distington-Goodman Rope Belt Conveyor Structure is relatively quick and easy.

(Right) Detail of a main stand and anchor point. These can be spaced up to 400′ apart according to requirements.

A 36″ rope belt conveyor installed at a quarry, carrying 500 tons of gravel per hour. By securing the rope to terminal pulleys it has proved practicable to move this conveyor bodily sideways by the dragline shown in the illustration.

BC9

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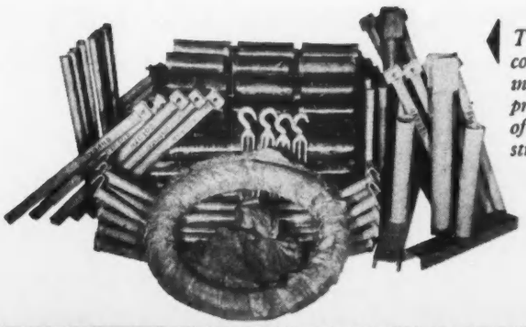

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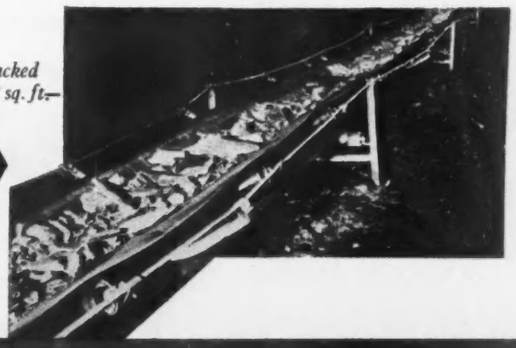
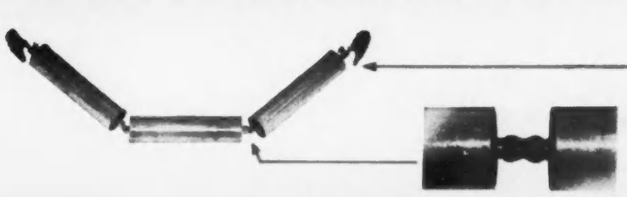


DISTINGTON-GOODMAN

ROPE BELT

CONVEYOR STRUCTURE
patented



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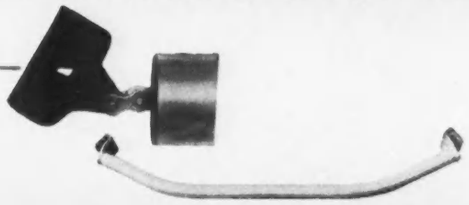

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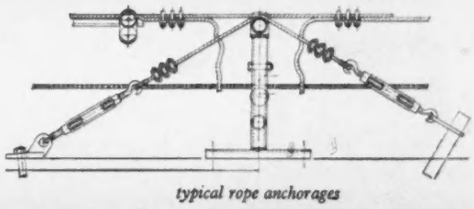

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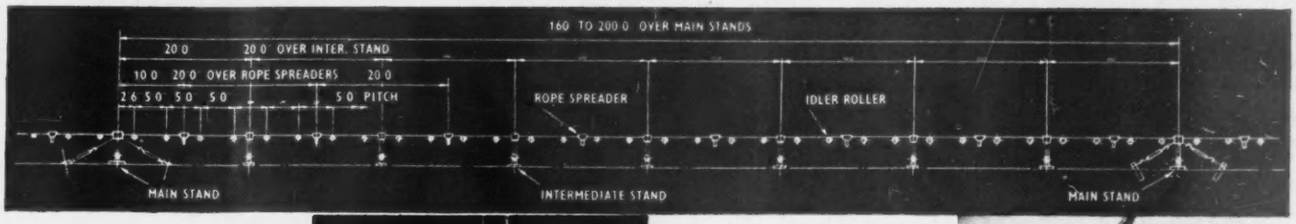

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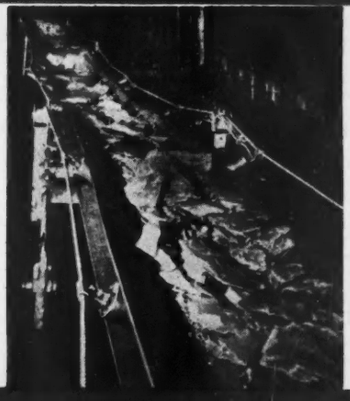

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Cast steel corrugated Slag Pot, weight approximately 10 tons.

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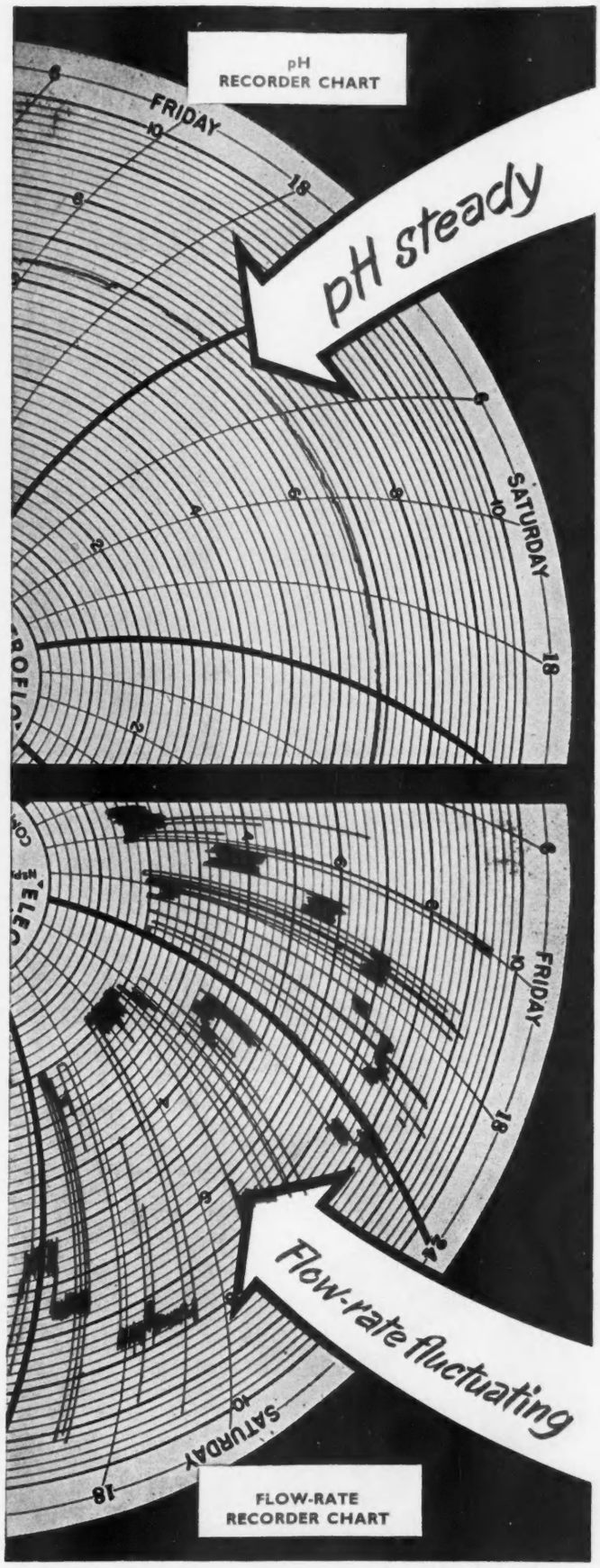
A wholly owned subsidiary of English Steel Corporation Ltd



pH CONTROL

Photographic reproductions of actual pH recorder and Flow-Rate Recorder charts on 'Boby' fully automatic acid dosing gear for pH control of cooling water for rubber extrusions. Installed at Goodyear Tyre and Rubber Co. (Great Britain) Ltd., Wolverhampton

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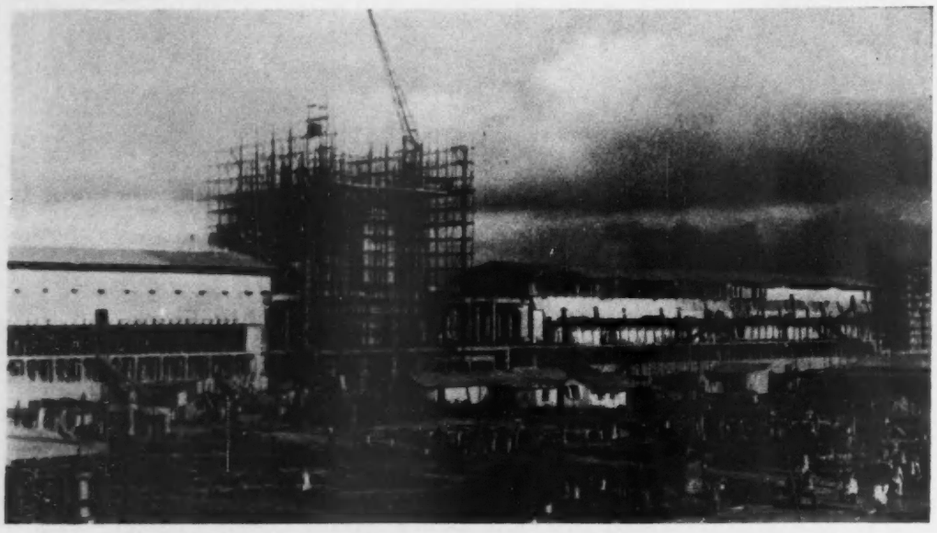
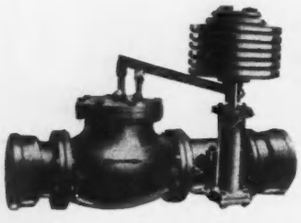


for Industrial Works

In most industries valves are required for controlling the flow of liquids, and in most cases such requirements can be met from the Glenfield Valve Range.

The site illustration shows part of the vast new steelworks being built at Durgapur for the Government of India, by the British Consortium, the Indian Steelworks Construction Company Ltd. For this huge undertaking several thousands of Glenfield Valves, in many different types, are being supplied for service in such elements of the plant as the coke ovens, power house, rolling mills, by-products section, and the process and domestic water systems.

Shown in cut-out form are examples of power- and hand-operated Sluice Valves, Pressure Reducing Valves and conventional single swing-disk Check Valves.



Glenfield

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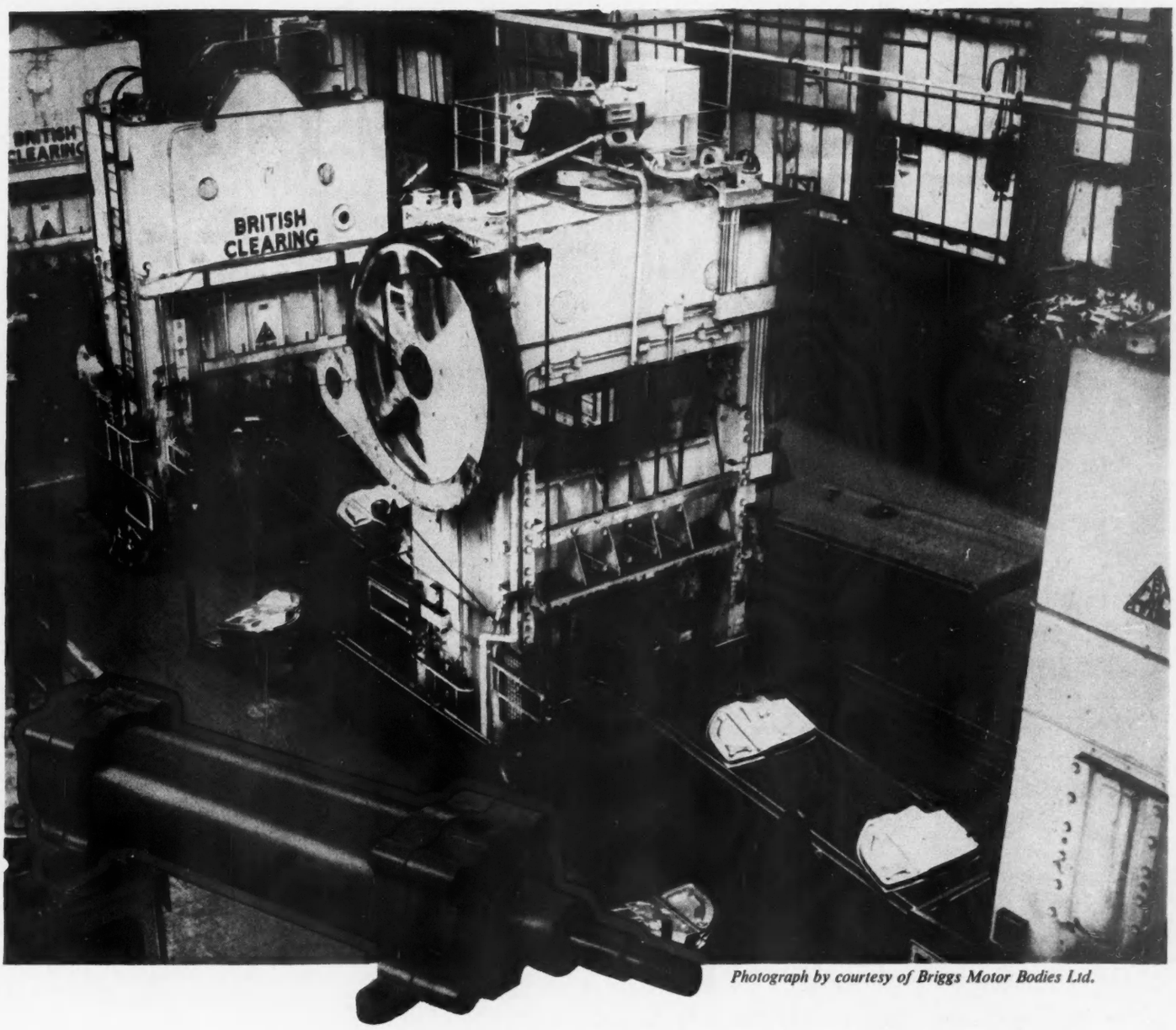

Photograph by courtesy of Briggs Motor Bodies Ltd.

'Fescol'-ised Air Cylinders help to keep Production Moving

The air cylinders supplied by Baldwin Instrument Co. Ltd., to provide power operation for automatic work handling devices, have 'Fescol'-ised bores and piston rods to reduce friction and ensure maximum life from seals. This is one further example of the way in which Fescol, who pioneered the electro-deposition of nickel and chrome for engineering purposes, still lead the way, adapting their process to help each new industrial development.

If you would like to know more about the process, and its use in preventing corrosion and protecting new machinery please send for publication No. EG.5

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Established 1920

FESCOL LIMITED · NORTH ROAD · LONDON N7

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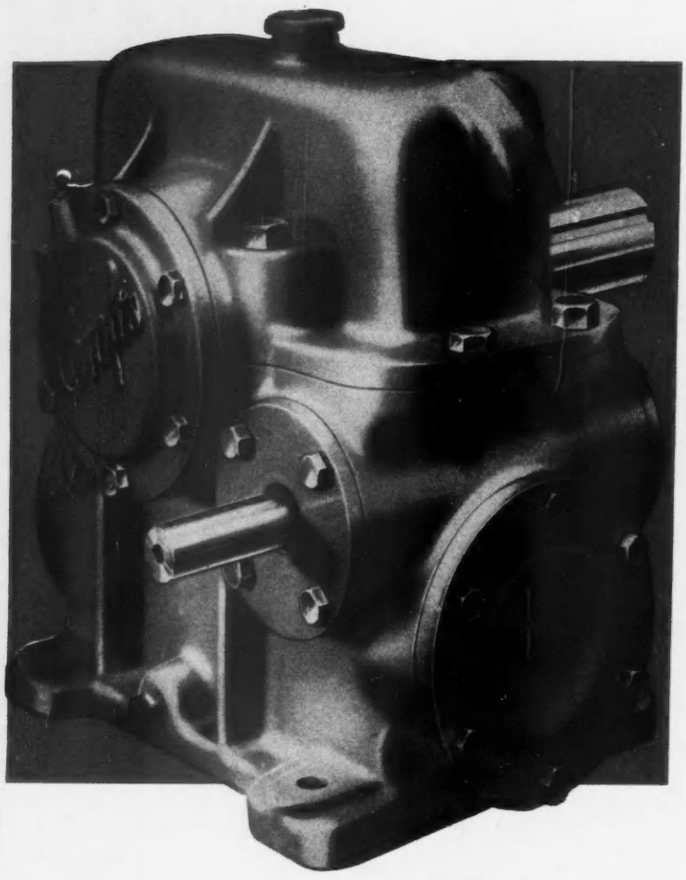
DOUBLE REDUCTION WORM GEARS

'HRD' High Ratio Horizontal Type



1 Specially designed to provide large speed reductions in one compact unit.

2 Enables high-speed motors to be used for driving machines, conveyors, etc., which are run at fractional or very low speeds.

3 Output shaft can be direct coupled, or a spur gear or chain pinion can be fitted.

4 Input and output shafts are in parallel, forming most compact drive, when arranged on baseplate with electric motor.

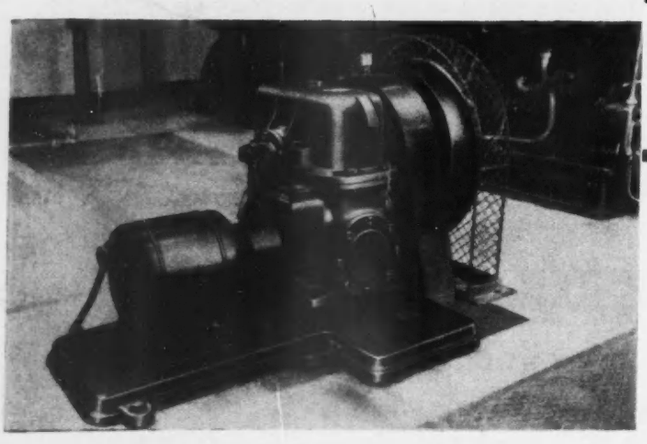
5 Units are also standardized as Geared Motors, the electric motor being flange-mounted to the gear case.

6 If desired, the first reduction layshaft can be extended beyond the case to form an intermediate speed output shaft, or to provide an auxiliary drive for limit switch or similar mechanism.

7 Precision built from highest-quality materials, including ball or roller bearings, with an additional roller bearing where exceptionally heavy loads are specified.

GEAR RATIOS UP TO 10,000 TO 1.
OUTPUT TORQUES FROM
2,000 TO 113,000 INCH/LBS.
LARGER OUTPUT TORQUES ALSO AVAILABLE.

Full technical data and Selection Tables in Publication 523/A.



Crofts "HRD" Worm Gear driving 22 ft. diameter Rotary Screens at Steelworks Pumping Station.

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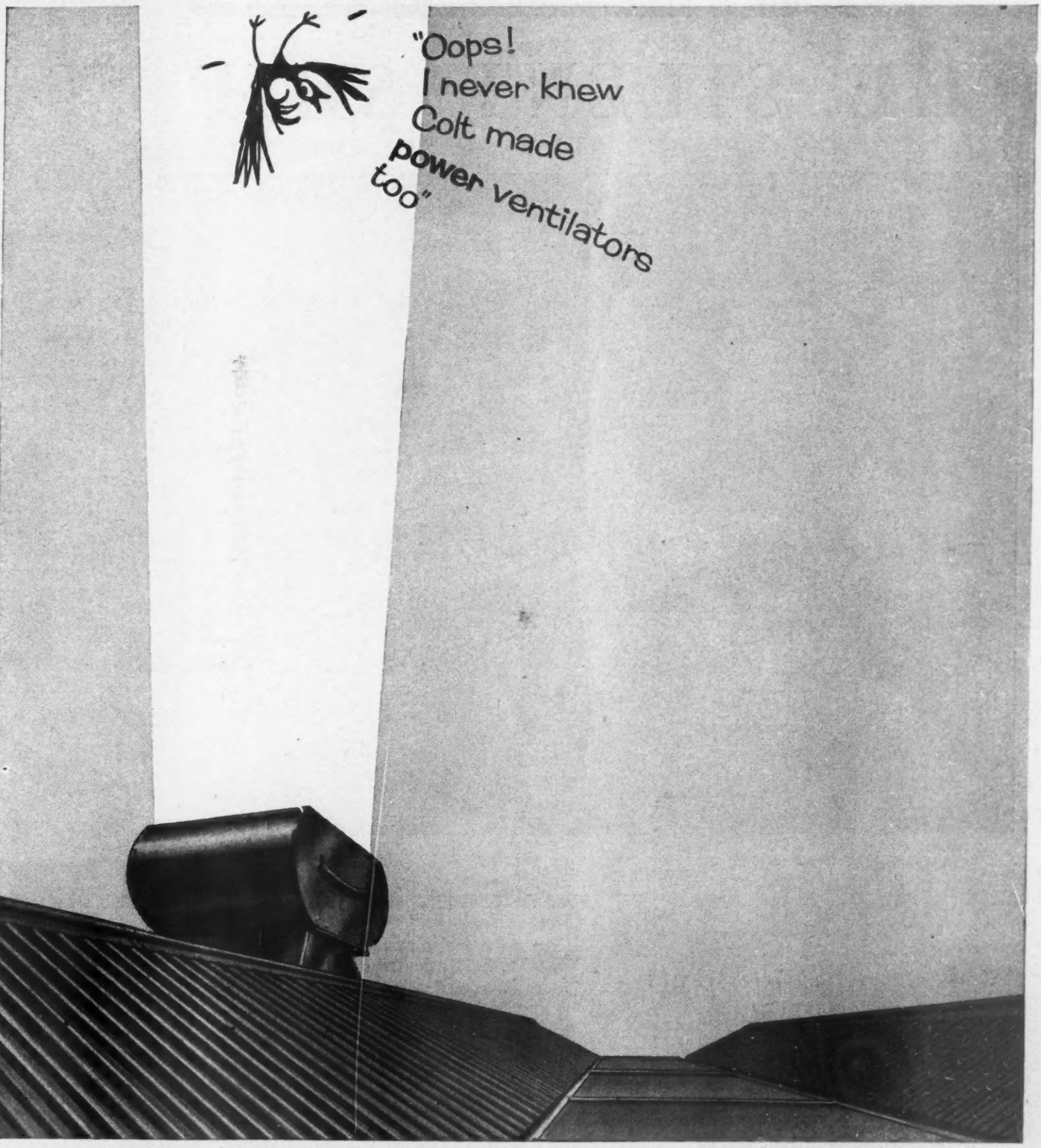

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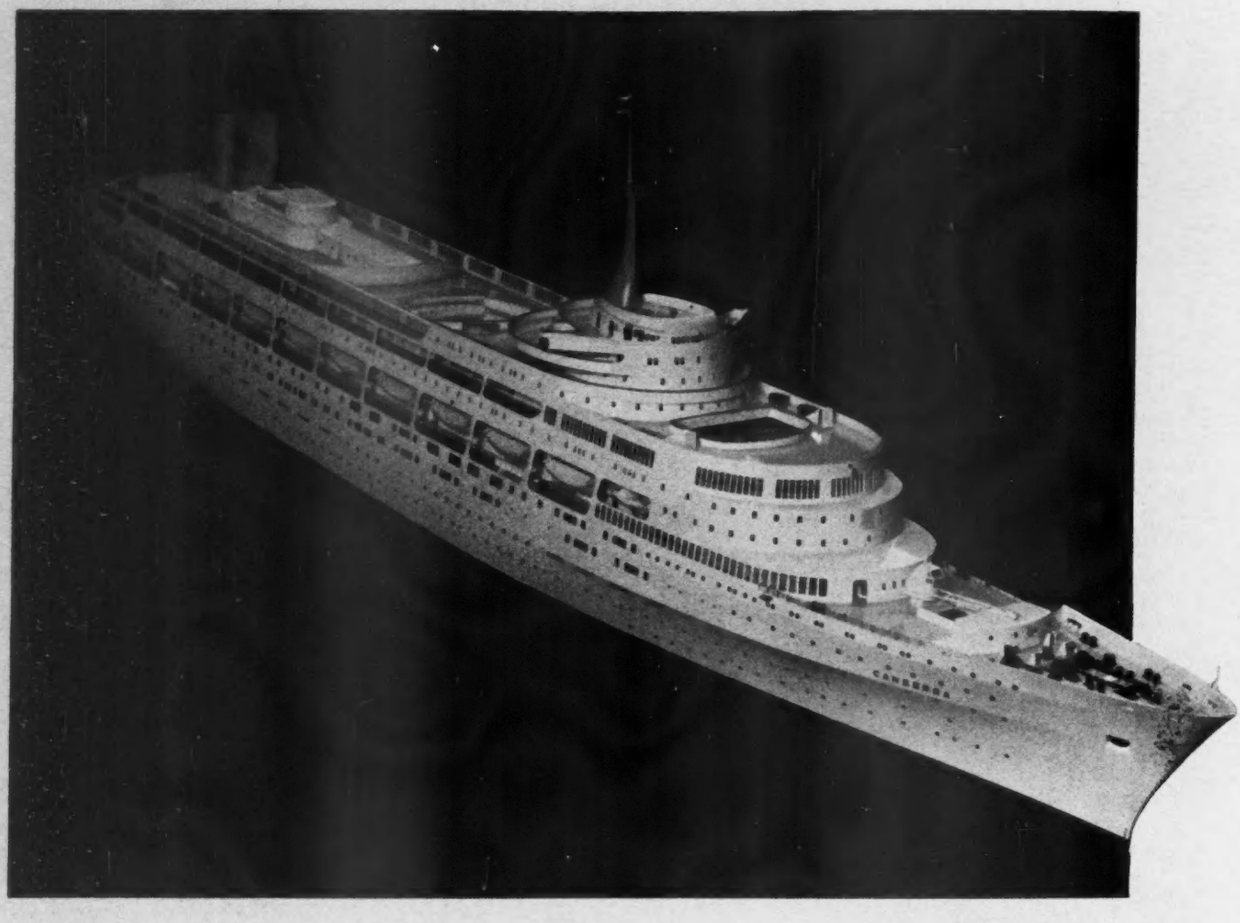

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For the Canberra, the world's most modern liner, high standards of Acoustic Engineering were demanded—and were met.

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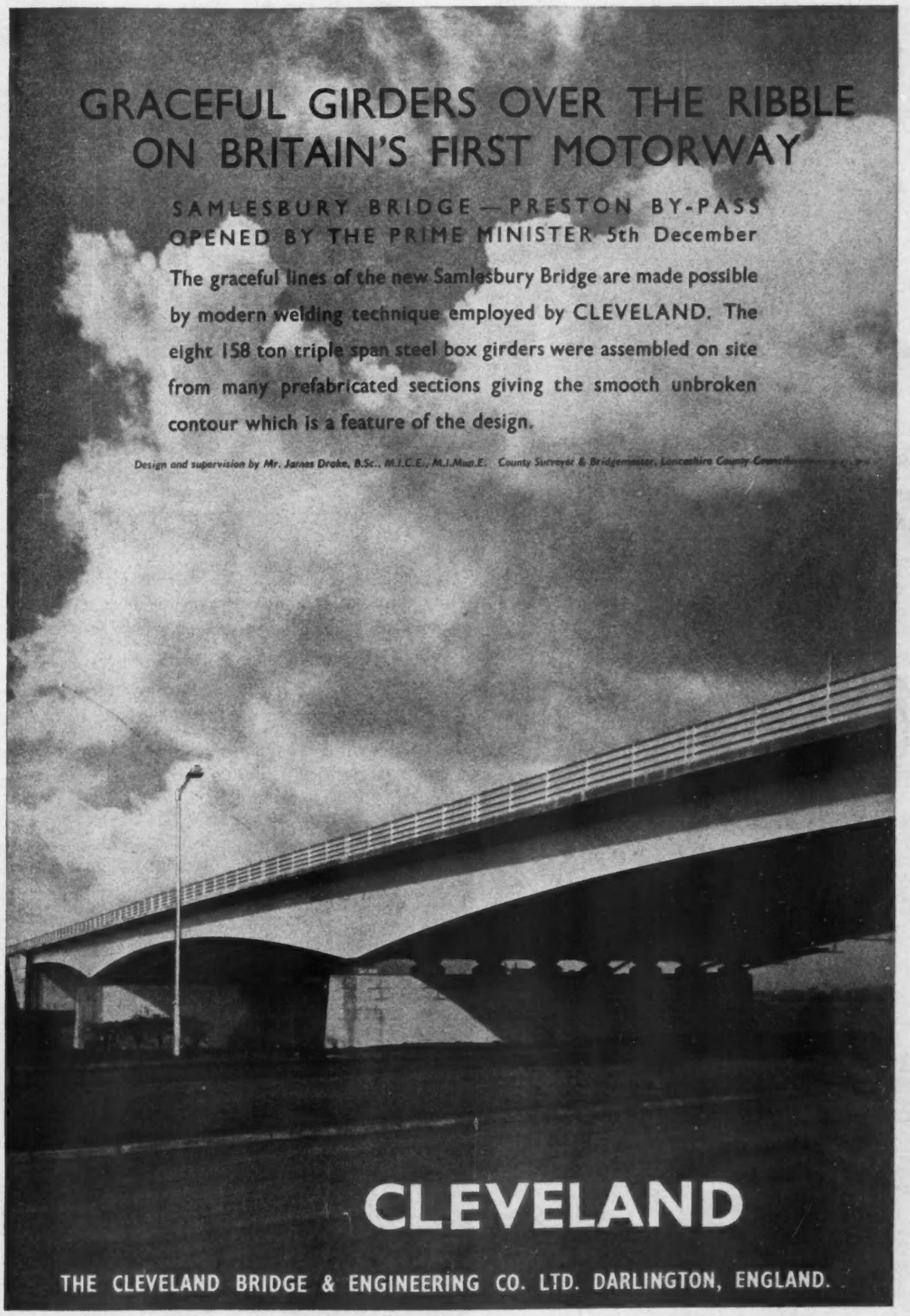
GRACEFUL GIRDERS OVER THE RIBBLE
ON BRITAIN'S FIRST MOTORWAY
SAMLESBURY BRIDGE — PRESTON BY-PASS
OPENED BY THE PRIME MINISTER 5th December
The graceful lines of the new Samlesbury Bridge are made possible by modern welding technique employed by CLEVELAND. The eight 158 ton triple span steel box girders were assembled on site from many prefabricated sections giving the smooth unbroken contour which is a feature of the design.
Design and supervision by Mr. James Drake, B.Sc., M.I.C.E., M.I.Mun.E. County Surveyor & Bridgemaster, Lancashire County Council
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THE CLEVELAND BRIDGE & ENGINEERING CO. LTD. DARLINGTON, ENGLAND.

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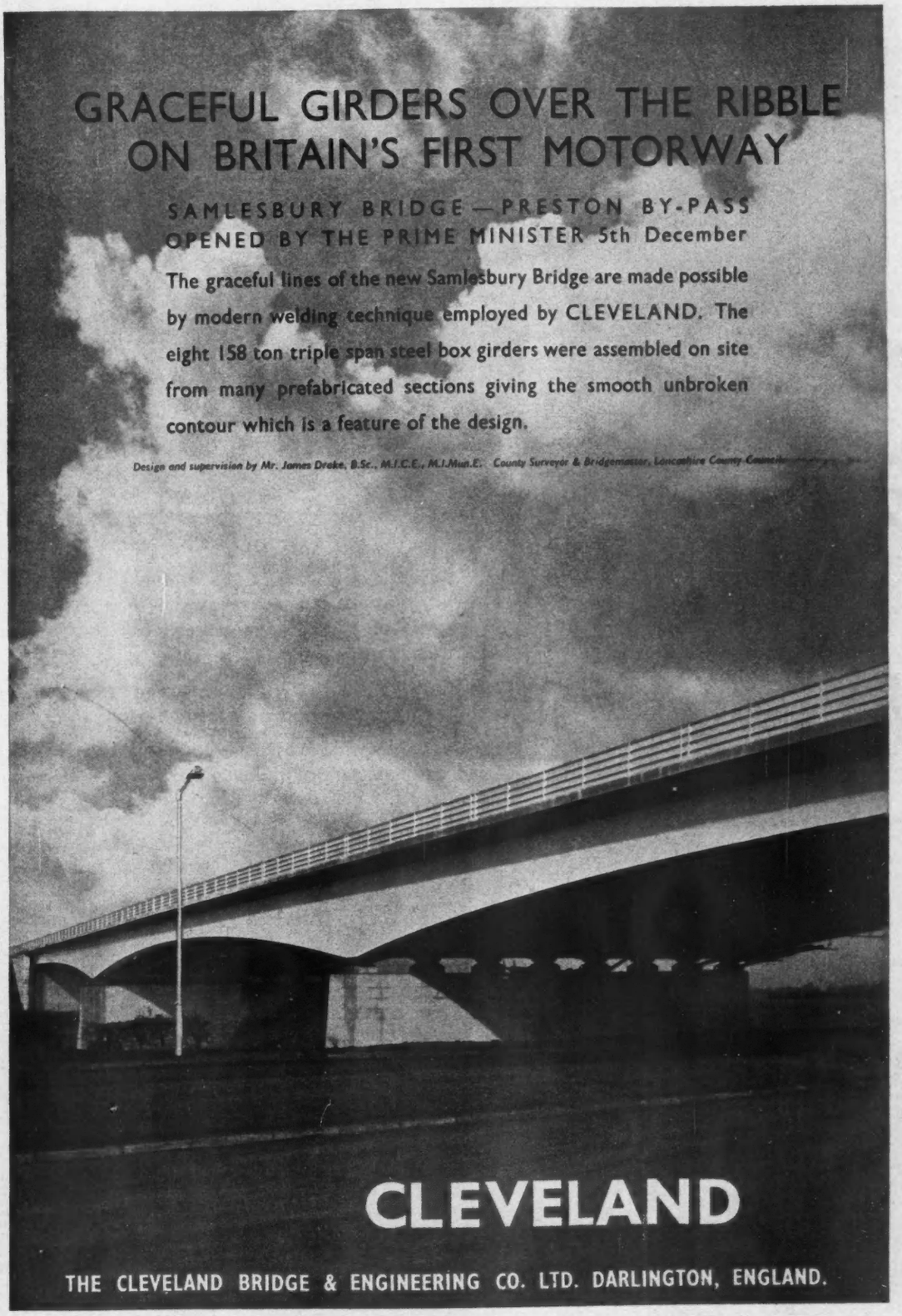
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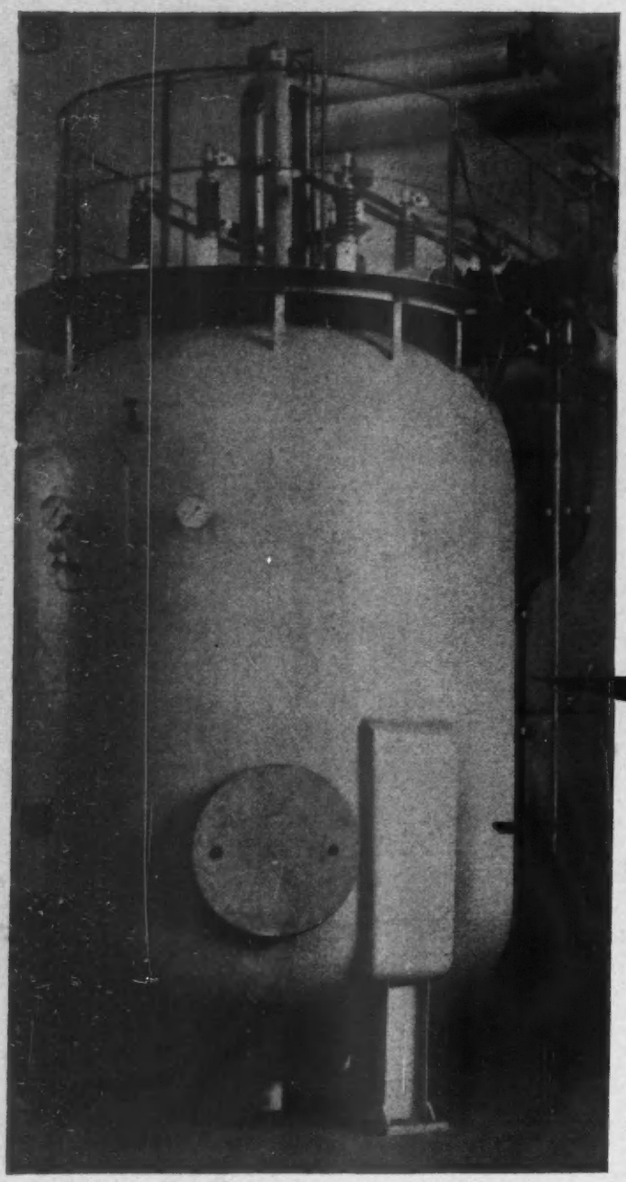

This electric boiler for high-temperature water is installed in a continental electricity works. It is rated at 10,000 kW and operates on a 6,500 volt supply, the pressure being 140 lb. per sq. in.

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Electric Boilers

Sulzer Electric Boiler Plants are the product of many years experience and research.

Fully automatic in operation they give a very high degree of efficiency and cleanliness, coupled with reliability and low maintenance costs.

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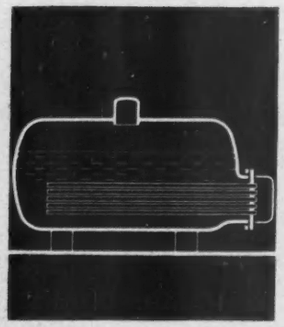
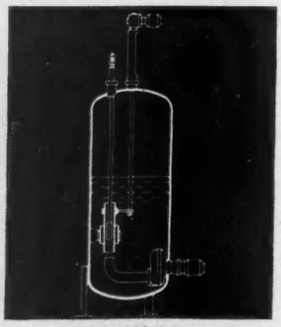
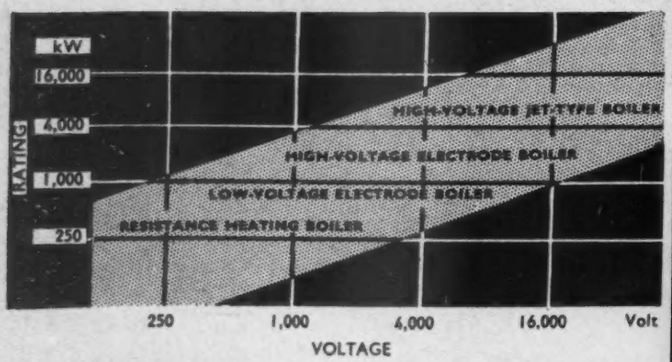


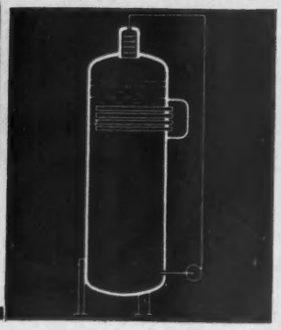
High-Voltage Electrode Boilers



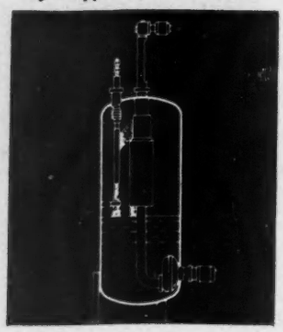
The ranges of application of the various boiler types overlap to some extent and thus completely cover the whole field of practical requirements.



Electric Boilers with Storage



High-Voltage Jet-Type Electric Boilers



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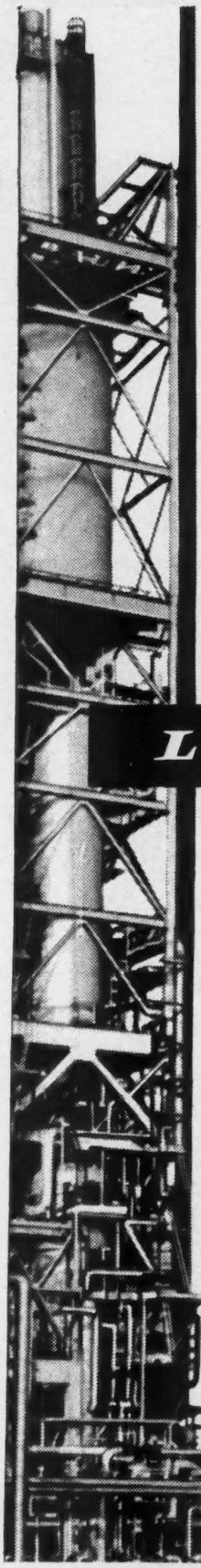

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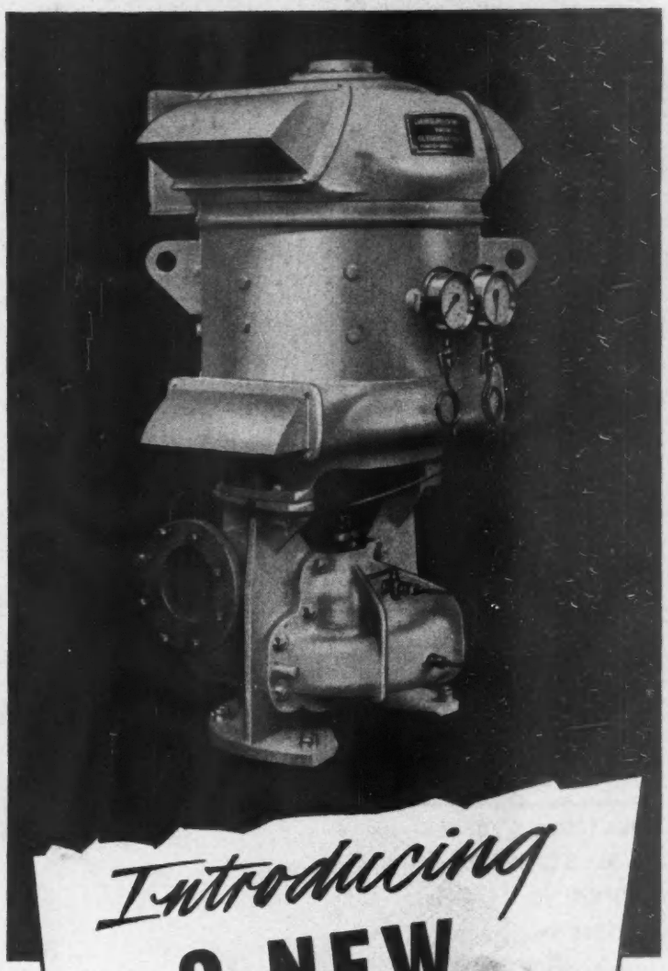

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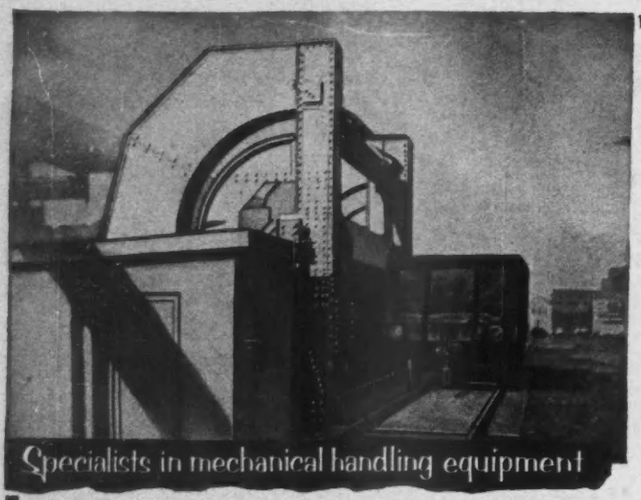

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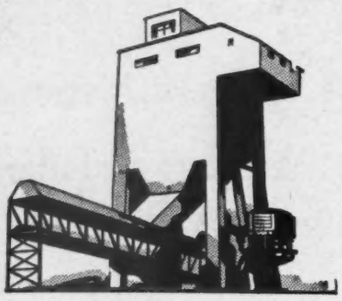

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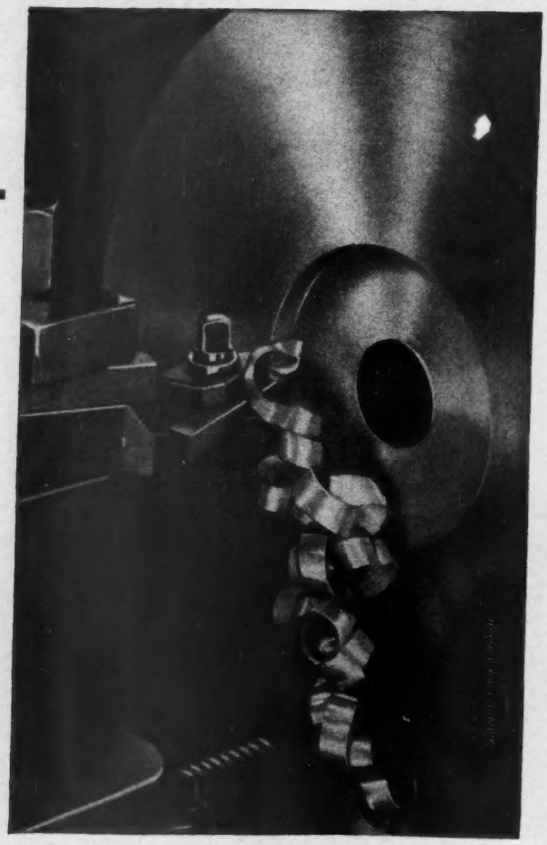

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tool bits
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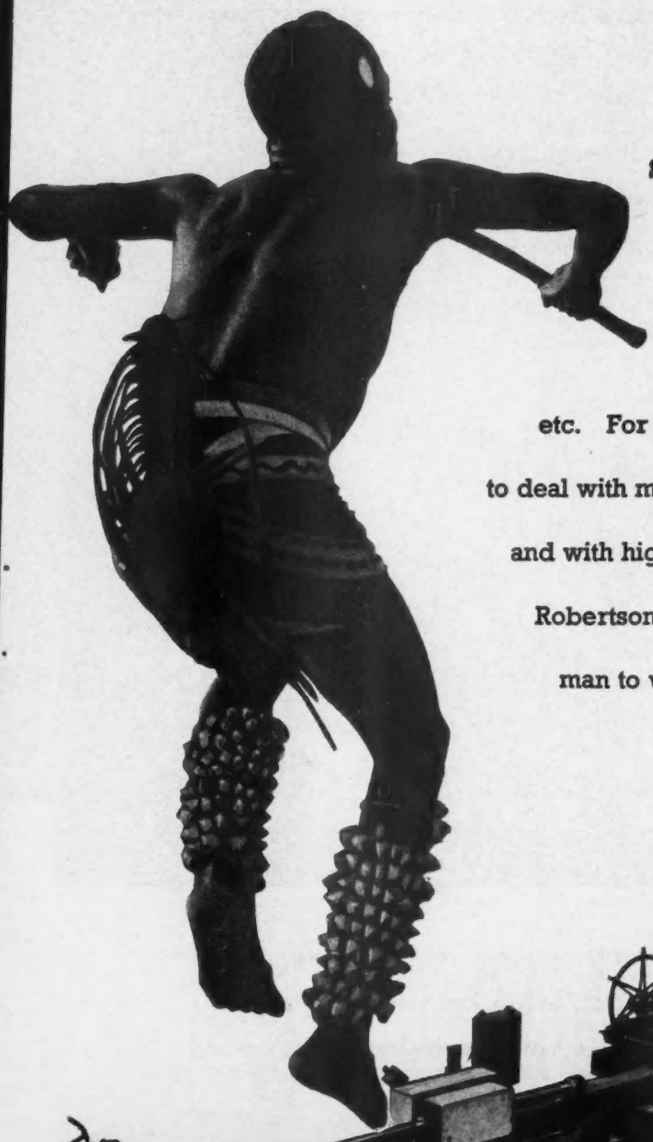
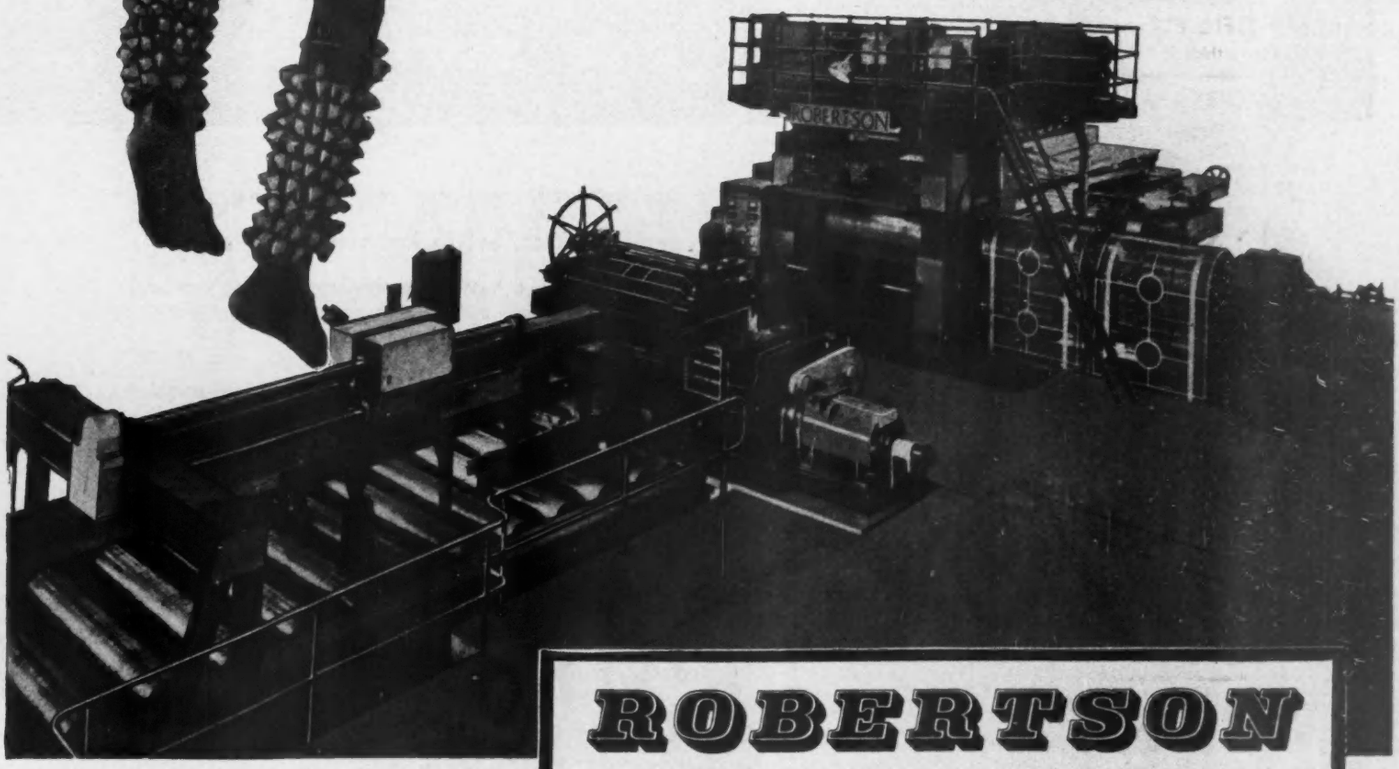
UTB



MAN AND MACHINES

Steel and many other metals have been worked for centuries but this modern age has discovered new metals and new uses for old metals and a demand for new machines to work the metals, new applications for the metals, metals in strips, tubes and wires, etc. For over 50 years, Robertson's have experimented, and built machines to deal with metals, machines built with performance and quality in mind and with high precision and high output in practice.

Robertson's machines, which are in operation throughout the world, help man to work metals ever faster, ever better and ever more accurately.



Photograph by courtesy of The Steel Company of Wales Ltd.

ROBERTSON ROLLING MILLS

Robertsons manufacture a wide range of equipment for steel mills, and the illustration depicts a 32"×80" two-high Sheet Skin Pass Mill installed in the Abbey Works of the Steel Company of Wales Limited.

(R) W. H. A. ROBERTSON & CO. LTD., BEDFORD, ENGLAND

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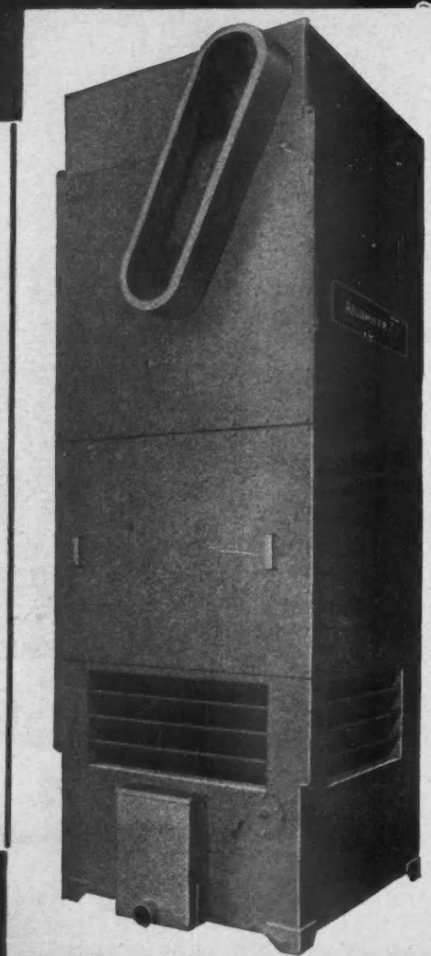
only a ripple on the surface, but ...



Day by day water losses may only seem a ripple on the surface, but looked at cumulatively they soon become a wave of unnecessary wastage and expense.

For all cooling systems where water conservation is necessary, specify

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MAKERS OF MIDAC DUST & FUME CONTROL UNITS & GYRA-FLO AIRFOIL CENTRIFUGAL FANS

PORTAL FRAMES OF UNIVERSAL BEAMS

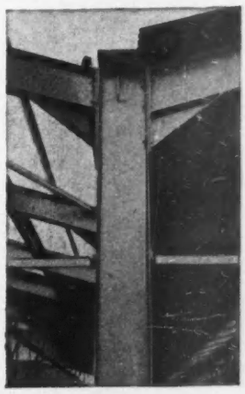
The illustrations show a building for the new wire mill at Ecclesfield for Arthur Lee & Sons Ltd. of Sheffield.

The portal frame structure is fabricated from Universal beams; each arch was dispatched in four parts, later connected by high-strength bolts.

A feature of the steelwork was the provision for overhead lifting equipment for which the runways were suspended from the arches by A-frames; these are visible in the upper illustration.

Engineers & Contractors:
Industrial Development and Construction Ltd.,
Stratford-upon-Avon

General view of apex bolted connection

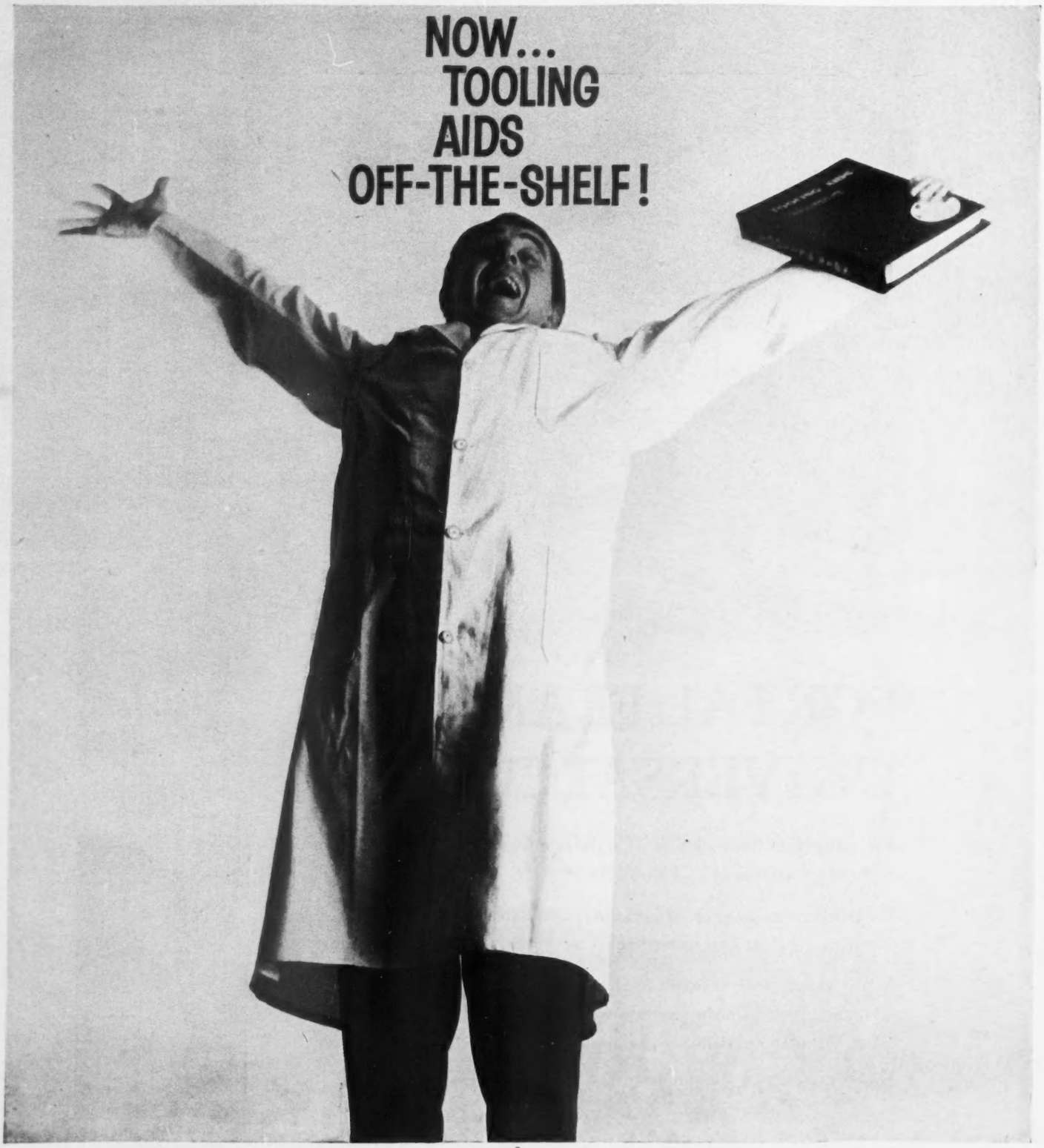


Detail of valley connection

STEELWORK BY

DORMAN LONG

STEELWORK IS CHEAPER AND READILY AVAILABLE



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more than 200,000 operations with

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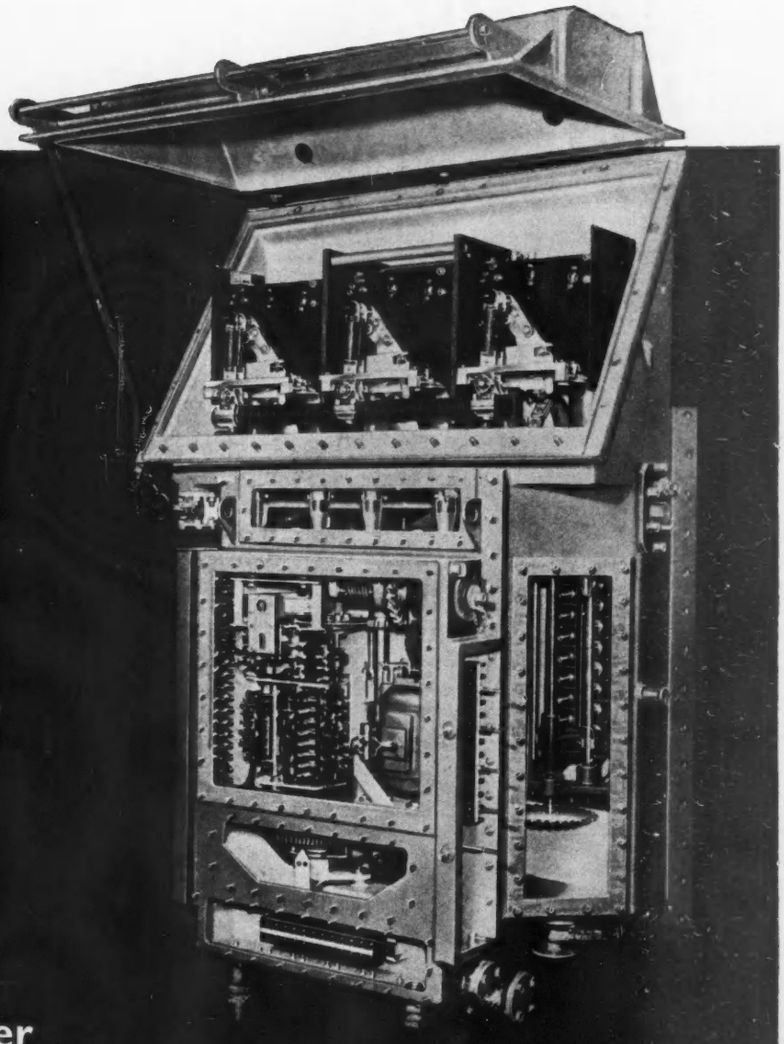

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High Speed Resistor
On-Load Tap Changer
Type D.C.3

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D4

Forged Steel Reinforcement Gas Duct Rings

As machined prior to installation 98″ o/d, 68″ i/d, overall width 24″ (by courtesy of Whessoe Ltd.)

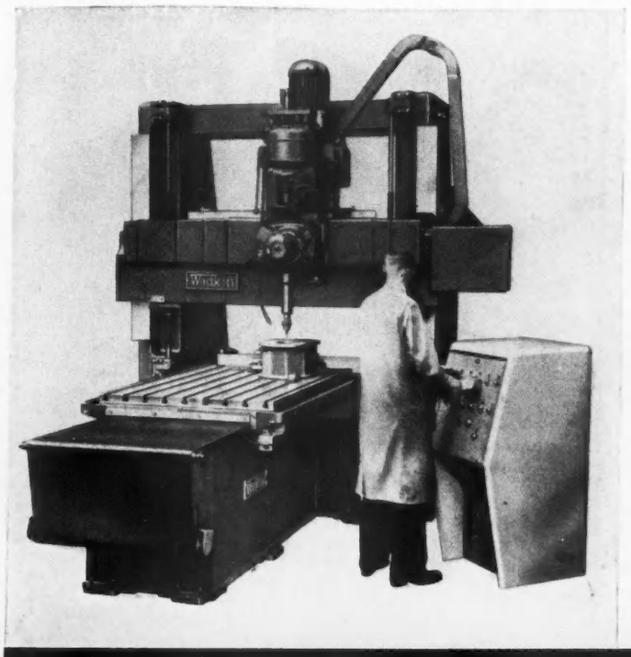
As forged and heat treated 101″ o/d, 65″ i/d, overall width 27″ (by courtesy of Whessoe Ltd.)

As machined prior to installation for 3′ 3″ bore inlet duct and duct erection opening for heat exchangers (by courtesy of International Combustion Group)

For Spherical and Cylindrical Vessels as supplied for the above NUCLEAR POWER PLANTS

Material B.S. 1503/151-1950, grade B, having excellent welding properties with Charpy V notch impact results of 25 ft. lb. average at −10°C.

The Darlington Forge Ltd DARLINGTON



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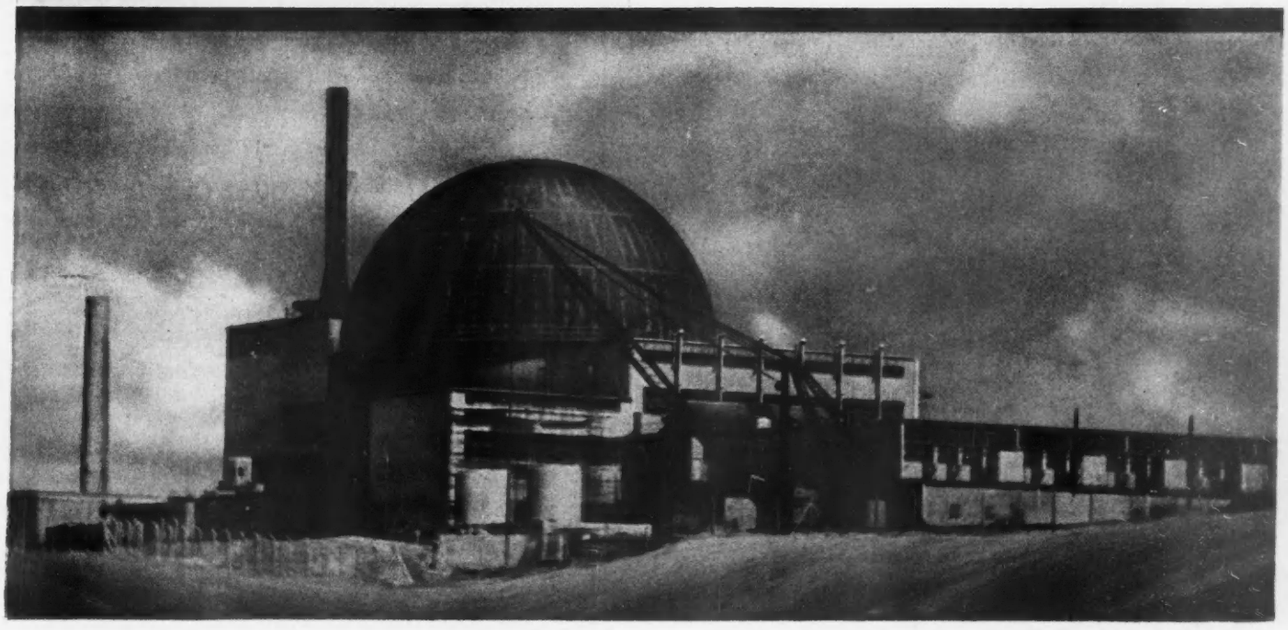

Rotax Recirculating Ball Threads are over 90 per cent efficient. All ball threads and nuts are completely reversible, but locking devices can be supplied if required. Stabilised and made of special materials, they remain accurate indefinitely. 'Clean' nuts simplify fitment.

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Operating load ..... up to 80,000 lb.
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Standard Pitches ..... 200″ 218″ 250″ 500″
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Shaft diameter ..... up to 4″
Life ..... 10,000,000 reversals
Temperature range ..... —90°C to + 100°C
(using special materials, temperature range can be extended up to + 950°C).

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International Machine Tool Exhibition 1960

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a bearing material in tube form from which you can machine your own dry bearings

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DQ dry bearing material, though neither quite as strong or quite as wear-resistant as DU, has, in itself and throughout, frictional and wear-resisting properties comparable with those of lubricated bearings, and it can be used at temperatures from −200° to +250°C. Absence of oil means that no contamination can occur with DQ, which operates even when totally immersed in liquid—often with improved performance—and is resistant to corrosion by many industrial liquids and gases, *including solvents*. It is tolerant of dirty surroundings. There are *no* static electricity phenomena associated with DQ, and it is entirely free from slipstick effects.

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Successful applications of DQ dry bearing material include:—Cold and hot service seals, pump bushes and thrust washers for industrial liquids and gases, including liquid oxygen and liquid nitrogen plant applications; mechanical movements for electronic computers and indicating and recording instruments; bushes etc. for hot water circulating pumps (submerged) and for compressors; textile machinery; aircraft controls and instruments; etc., etc.

Further new applications for DQ Dry Bearing Materials are waiting for designers who can take advantage of the properties of this very remarkable material.

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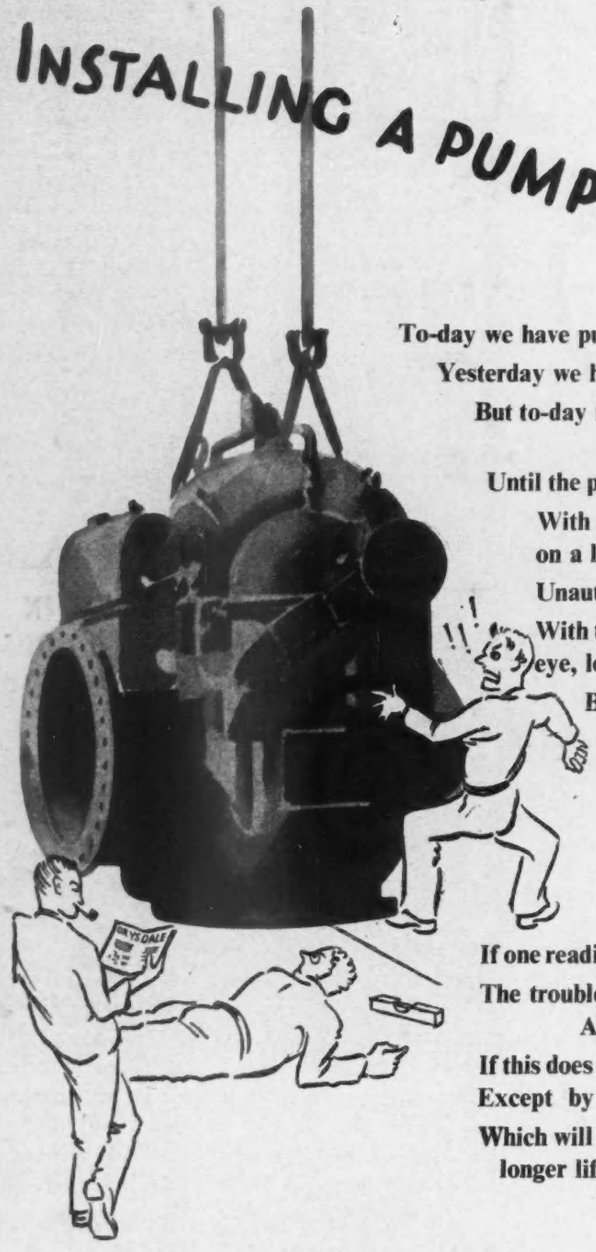
INSTALLING A PUMP



To-day we have pump installation or installing a pump
Yesterday we had naming and fitting of parts,
But to-day it's installing a pump.
There is no point in worrying unduly
Until the pump has been removed from its packing case,
With this done draw a bead with blue chalk
on a level surface,
Unauthorised persons should now be ushered away
With the blue chalk marks firmly fixed in the mind's
eye, lower away,
Bad language generally denotes a foot under
the bed plate
This should be removed as the flatness of
the level surface is important,
When the pump is bedded down
Take periodic readings
Say from two point five to twelve.
If one reading conflicts outrageously—stop immediately!
The trouble should be investigated and when found
Abrasive paste should be applied,
If this does not eliminate the trouble, it can't be helped
Except by reading the Drysdale official instructions
Which will ensure perfect alignment and consequent
longer life for the pump.

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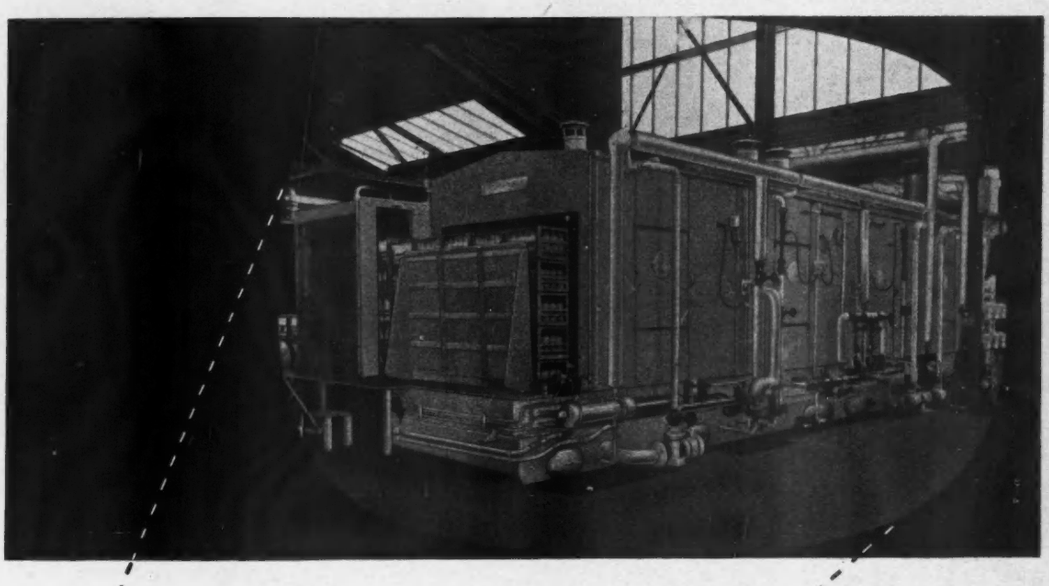

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It can be worked and welded as steel, comes in a wide range of plain or embossed surfaces and is used to fabricate among other things, lifts, doors, car panels, partitioning, furniture, kitchen equipment, walls and cladding—all of them colourful and permanent. Investigate Stelvetite. It may well save you a small fortune, or a large one.

Stelvetite Plastic bonded to Steel

All enquiries about Graham-Enock Dairy Steralisers should be made to Graham-Enock Manufacturing Co. Ltd., Windus Road, Stamford Hill, London, N.16.

STELVETITE—made by John Summers and Sons Limited, who produce over 52,000 miles of sheet steel every year. Write to us at Shotton, Chester, for full information.

"qualified engineers and scientists: analysed by profession and industry"

Published by ENGINEERING, "qualified engineers and scientists: analysed by profession and industry"; a chart showing the distribution of the different types of professional engineers and scientists in the British manufacturing industries, building and contracting and in industrial research associations. It can be seen from this chart, for example, how many electrical engineers are employed in constructional engineering, chemicals and allied trades, the manufacture and repair of aircraft—the chart also shows the total number of engineers and scientists of all types employed in these and other industries.

Copies of this chart are supplied *gratis* by ENGINEERING, 36 Bedford Street, London, W.C.2. Telephone: Temple Bar 3663.

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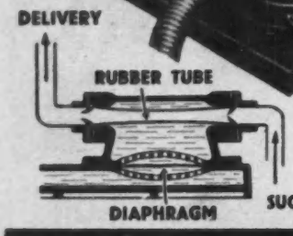

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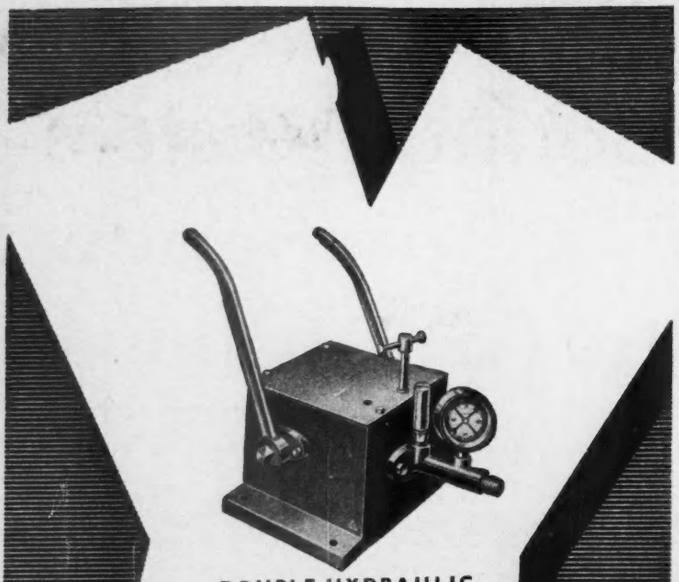

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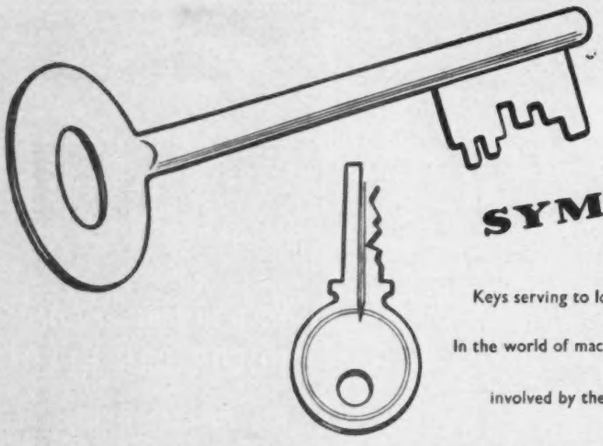

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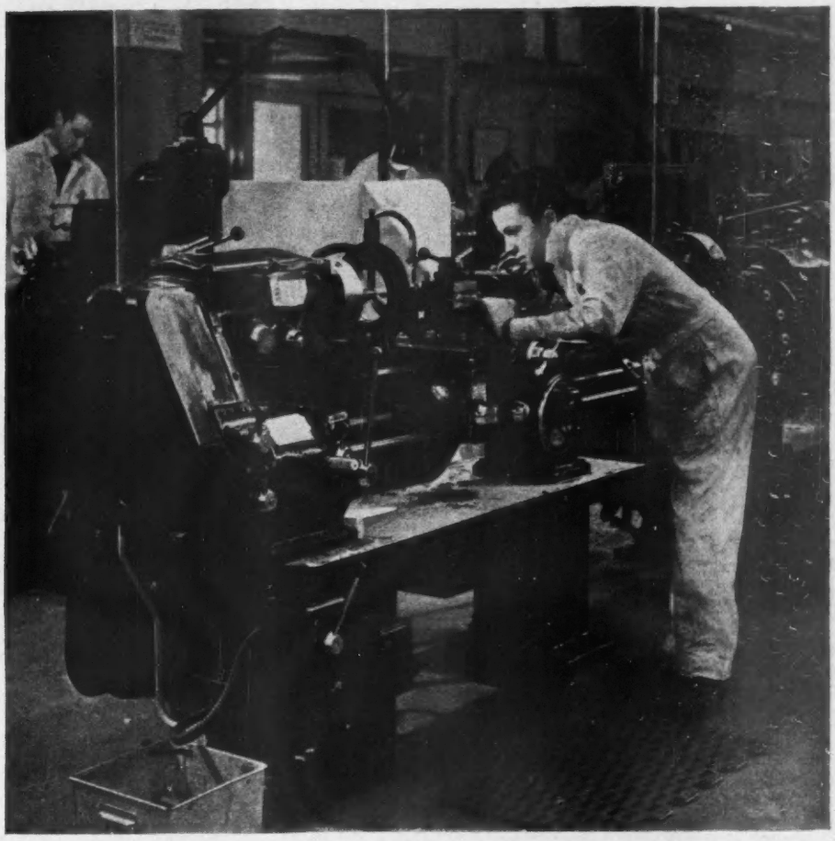

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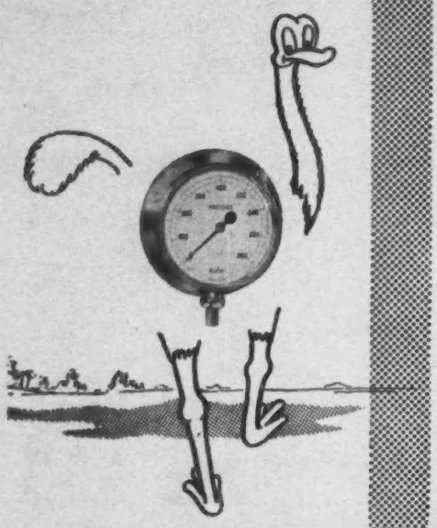

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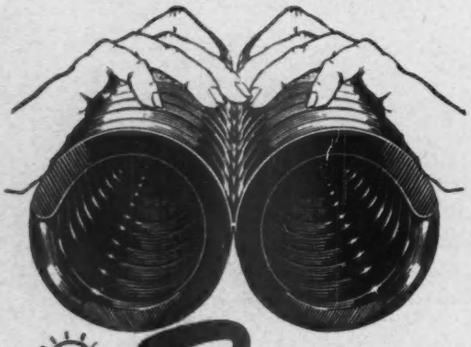
Looking in the right direction



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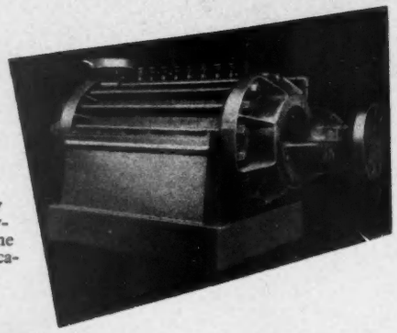

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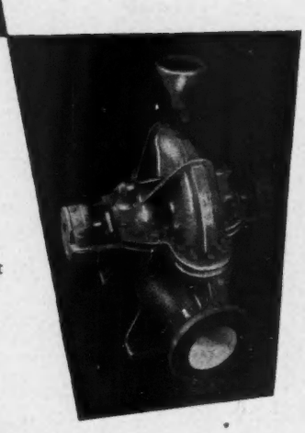

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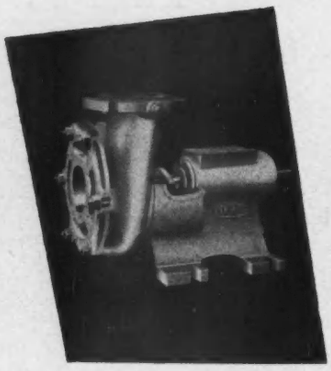

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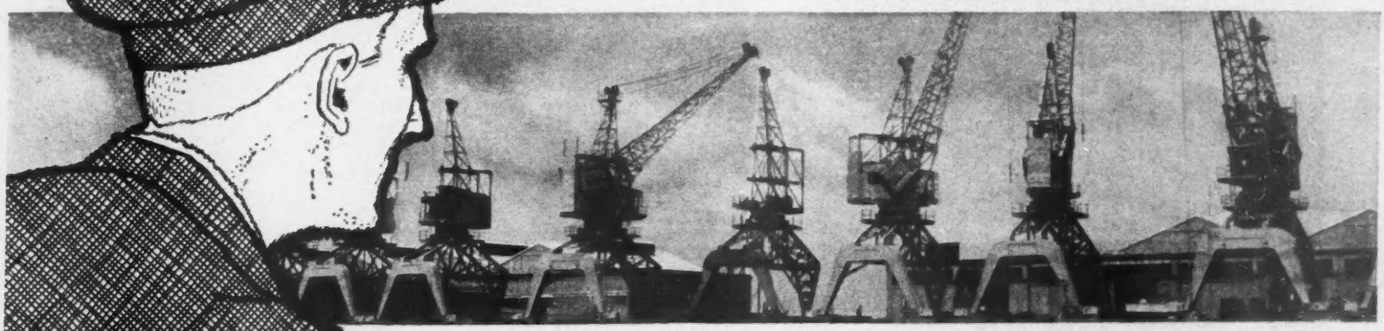
G 1

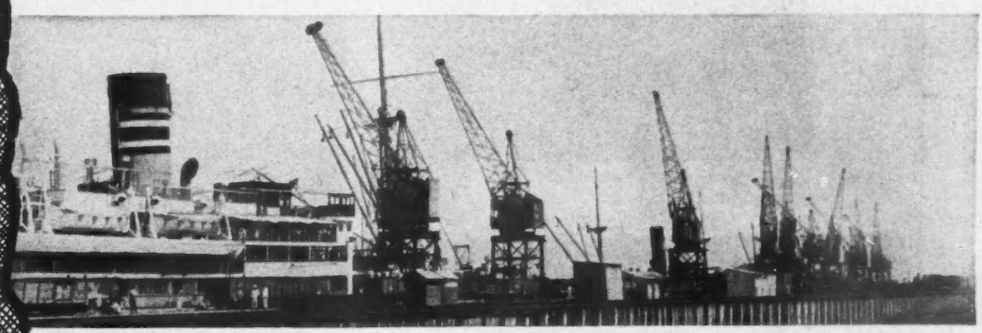
Silhouetted against a grey London sky these Stothert & Pitt 3 and 5 ton cranes with maximum radii varying from 65 ft. to 90 ft. stretch as far as the eye can see.

P.L.A. LONDON



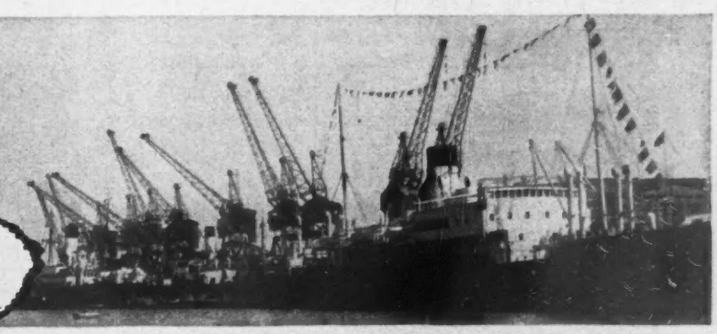
Many thousands of miles away, 3 ton cranes with 3 legged trucks and a maximum radius of 75 ft. speed up cargo handling in India. Also in use at the same port are 6 and 10 ton cranes with maximum radii up to 75 ft.

KANDLA, INDIA



In East Africa, the use of Stothert & Pitt 3 ton cranes with a 55 ft. maximum radius ensures the quick turn round of large cargo ships.

BEIRA, EAST AFRICA



Always busy are these 3/5 ton semi-portal cranes with maximum radii of 96 ft. and 69 ft. which dominate a dockside scene in Sweden.

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G217

ENGINEERING Impact

of Re-shuffling the Railways

ENGINEERING firms who supply British Railways can reasonably expect good news before the end of the year.

It is over twenty years since such firms could call on several railways when they had a new product or design to sell. Since nationalisation of the railways in 1948, there have been frequent complaints from engineering firms that the whole selling operation has to be concentrated on one person at the Transport Commission headquarters. If you fail with him there is no where else on British Railways to try.

The Planning Board, which is now examining the Commission's railways and allied systems, is expected to report to the Prime Minister on how management may be decentralised. We may therefore see a reversion to a system much more like the old railway company organisation, so far as autonomy in technical development is concerned.

Of the four members of the Board appointed from industry, three are technical men of wide managerial and industrial experience. Sir Ivan Stedeford (chairman and managing director of Tube Investments Limited) was an engineer apprentice at Vickers. Mr. C. F. Kearton (a managing director of Courtaulds Limited) took a first-class honours degree in chemistry at Oxford and has since had much to do with chemical and atomic engineering. Dr. R. Beeching (technical and development director, Imperial Chemical Industries Limited) took B.Sc., first-class honours, at Imperial College, spent some time with Mond Nickel and in the Armament Design Department, and was closely connected with ICI's production of Terylene.

The Transport Commission, headed by their chairman, Sir Brian Robertson, have encouraged the railways to use management consultants in promoting greater efficiency. On a higher level a similar consultancy function is being performed by the Planning Board.

The Board's report, however, will go to the Government, not the Commission.

Timing and Development of Nuclear Programmes

The International Atomic Energy Agency is engaged in a world study of nuclear power prospects, with special reference to under-developed areas. A general survey is being made of nuclear generation costs and a panel on nuclear power costing is about to be convened by the Agency.

Progress has already been achieved in technical studies aimed, in the first place, at evaluating power reactor types, with special reference to the state of their development, operating experience and prospects of future development; and secondly at determining the technical requirements for power reactors to be used in less developed areas.

The economic and technical aspects of small and medium power reactors will be reviewed at a conference to be held by the Agency in September this year. Now clearly is the time for Britain to decide whether or not to play a part in these developments.

Several small reactors potentially suitable for use by the less developed countries are under construction in some of the advanced countries, and the United States of America has proposed that the International Atomic Energy Agency should participate in the work of designing, constructing and bringing certain reactors into operation.

Here then is the opportunity. There is already one project on British soil directed towards the development of small high-temperature gas-cooled reactors—the international project Dragon, based on an original British concept.

With the Government's decision to proceed with tenders for a nuclear ship, it seems likely that small reactors remote from the apron strings of a research establishment may soon be considered acceptable. At the same time the IAEA survey of nuclear power prospects throughout the world may indicate where such reactors might economically be used for generating power. Australia, Africa and Antarctica, let alone Finland, South Italy and Argentina, invite United Kingdom enterprise.

The time is ripe for pressing Britain's interest in the small reactor field, and demonstrating that Commonwealth development is not to be left entirely to others.

Meeting Development Costs

The cost of developing a small nuclear reactor has been given variously as between £10 million and £100 million. This investment would be approximately equivalent to the cost of building one large nuclear power station. Since Britain depends on exports, and since only small reactors appear to offer good export prospects, it is surprising that this investment has not been found.

Small reactors also present Britain with a peculiar dilemma. The United Kingdom has no use for small reactors and hence is disinclined to build a prototype. But no overseas customer is likely to purchase a reactor that has not first been tried successfully at home.

There are four ways of tackling this impasse.

Firstly, British firms may take advantage of United States experience by building American reactors under licence, and benefitting from the lower fabrication costs in Britain. Secondly, a nuclear ship may be built and the small reactor developed for this purpose used as the basis of a power station. Thirdly, we may take a reactor in a comparatively advanced stage of development and site a prototype in an area that is sufficiently isolated to profit from the unique advantages of nuclear power, but near enough to a research establishment, to permit reasonable facilities for maintenance and development.

Fourthly, the Government could find the money to build a prototype at a site in Britain. The technical and scientific authorities in this country are at present in favour of concentrating on the present atomic power programme to avoid dissipating British effort on fruitless excursions. But in the light of existing plans for a nuclear ship, the Government and their counsellors appear to be divided on this issue.

of Small Nuclear Reactors

There are two situations in which nuclear power shows promise today: in highly developed areas where existing fuels are inadequate to meet the prodigious demand for power and in certain remote localities to which bulky conventional fuels can only be transported at a prohibitive cost.

In highly developed countries, heavy electrical demand and the prevalence of grid systems favour the large reactor with its economies of scale. Such countries will also have the technical experience to build their own.

The export market for large reactors is therefore likely to be limited. Remote areas, where power demand will in general be comparatively modest, call for small reactors, which consequently offer the best immediate prospect for sales abroad.

Britain's main effort has been devoted to large reactors designed to meet her domestic needs, but now a number of companies are planning small reactors for the export market. Projects ranging from 11 to 60 MW in electrical capacity and employing several different reactor systems are described for the first time in articles prepared exclusively for ENGINEERING by heads and chief project engineers of atomic-energy departments in eight leading British companies.

The articles, together with tables listing the names, addresses, associates and activities of reactor companies throughout the world, appear in this issue.

Vertical Take-Off and Air Transport

The successful passing of the Short SC1 research aircraft through the critical phase of changing from jet-borne hovering to wing-borne forward flight opens a road to revolutions in air transport as great as those promised by the Hovercraft.

The advent of the Mach 2 intercontinental airliner could in the not distant future bring New York as close in travelling time to London Airport as that vast terminal is from the traffic tangled centre of London.

The break through from this antiquated interference with the full elimination of distance by air travel could come from the use of VTOL airliners landing in their own length in city centres.

Since taking the noise out of engines is still inseparable from losing essential power, such airliners are not likely to be welcome at ground level.

In London a tower block more than 350 ft high is now going up.

An even taller block, covering a greater area, would be a lively challenge to the civil engineers. There on top of this 20th Century equal to the pyramids VTOL airliners, straight in from the other side of the world, could put down their passengers within a lift ride of the House of Commons or Piccadilly.

Given that the civil engineers could provide a summit strong enough to carry 100 ton aircraft, and that the passengers were willing to embark on a prodigious lift journey, there is no reason why such a mid-city air station should be lifeless at pedestrian level.

Companies might well be queueing to take office space. Its rateable value in use as shops would be outstanding.

Such an air station would, incidentally, give literal meaning to the words London Airport.

Re-equipping the Churches

As a result of "planned giving" campaigns, the purchasing power of the churches is going up. One estimate is that the £20 million spent annually on maintenance and equipment will soon double to £40 million.

There are at least 30,000 churches of the major denominations in England and Wales—about half of them Church of England. A high proportion need money for renovation and re-equipment. In many parishes the new money is now being found, often with the intensive help and advice of one of the planned giving consultant firms. By running a brisk campaign lasting about six weeks, the annual income of a typical church is trebled and the members of the church pledge to give at the new rate for the next three years.

Heating equipment is usually high on the list of priorities. The Central Council for the Care of Churches believe that more new heating installations are going into churches today than at any time before. Thermodare (Great Britain), who specialise in infra-red, thermal storage and warm-floor systems, received a thousand inquiries from churches after one advertisement.

The General Electric Company have devoted special attention to improvements in church lighting. Ecko have concentrated on tubular electric heaters; Bastian and Allen Limited on electrode boilers; F. A. Borchardt Limited on gas heating (an important technical problem had to be overcome—avoiding damage to organs by waste fumes).

Maintenance and Equipment News for Churches is the title of a magazine which was started last year to help this remarkable development.

Getting Tough about Research Support

A vigorous policy for the support of research in their industry has been adopted by two trade federations.

They are the United Tanners' Federation and the British Kid Tanners' Association. Together representing about two thirds of the leather industries the two bodies have now made belonging to the British Leather Manufacturers' Research Association a condition of membership.

This step alone should raise the research association's income to £35,000 a year and the degree of its support from 60 per cent of the firms in the industry to 75 per cent.

Dangerous possibilities of falling income have faced the research association in recent years as synthetic soling materials and duty free Commonwealth imports of chrome upper leathers forced tanneries to close down.

Changed terms of financial aid from the Department of Scientific and Industrial Research will also affect BLMRA's balance sheet. At present the association has to raise an income of £33,000 from the industry to qualify for a DSIR grant of £16,000. From October, 1961, BLMRA will have to earn £36,000 to attain the £16,000.

Plastic Ideas in Architectural Sculpture

Plastic binders with natural aggregate offer a relatively inexpensive medium for architectural sculpture. Cubitts are developing services for architects and designers in exploiting them.

EXCITING patterns such as that shown in the illustration can be made comparatively cheaply and easily in relief concrete or in a new material called Skinstone. The people who are working on both the method and the materials are Holland & Hannen and Cubitts (Great Britain) whose staff members in the surfacing development department are having a great time devising new methods of bringing our sometimes dull modern architecture to life. Surprisingly, perhaps, the mainstay of their work is the use of plastics, especially polyesters, epoxies and polyvinyl alcohol, which are employed as binders for the whole range of natural and synthetic aggregates.

By incorporating precoloured sands, terrazzo, crushed graded cockleshell, granite chips and many other aggregates in a clear but immensely strong plastic binder, a surfacing material is produced which has the strength to be self-supporting when making thin moulded facings, or will adhere strongly to concrete in the manufacture of composite slabs. This, in fact, sums up the two main developments of Cubitts.

Their product, called Skinstone, is a polyester resin filled with silica sand which perhaps not surprisingly looks very much like a real stone. This is especially suited for making thin moulded facing panels into the back of which can be cast concrete as the first stage in making a composite building slab.

Polyesters are also used for simulated marble and stone. These filled resins will withstand weathering and can therefore be used on the out-of-doors side of composite slabs. Epoxy resins are more suited to internal surfacing materials, and Cubitts use them for simulated stone facings. They have much higher adhesion to both metals and concrete than polyesters. Polyvinyl alcohol resins are being used primarily as a bonding medium, especially for bonding concrete to plaster by precoating with a mixture of this and sand.

These plastic materials have to be made under controlled conditions which present some difficulties to the uninitiated, and by far the best way is for them to be made in a central works. Cubitts, for instance, would wish to keep control on these products by making them in their own engineering departments. Another advantage of this would be that several moulding methods which have been developed in the course of this work could be exploited. One of the most interesting is use of pvc foil. Starting with the plaster master, an inverse mould is made by vacuum forming which has walls up to about 3 in deep and can be up to 3 ft 6 in square in size with present arrangements. This pvc mould can then be used to make a concrete or Skinstone relief moulding.

A quick method of producing sharp reliefs on an otherwise flat surface has been to cut the inverse of the pattern in expanded polystyrene and to use this directly as the mould after coating the polystyrene surface with a release agent.

Cubitts have faith in the composite panel and the plastic coatings are admirably suited to such outlets. This following combination, for instance, would have the same weight as a lightweight aggregate concrete but would have the advantage of containing a strong, dense concrete layer for load bearing: outside layer—a Skinstone moulding into the back of which is cast 5 in of concrete; middle layer—a 1½ in layer of woodwool board insulation permanently joined to the concrete by applying when the concrete is still wet; and inside layer—¾ in of Carlite plaster, which itself can be made with a more perfect surface under the strictly controlled conditions of a mass-production shop. Variations in the facings include a cast concrete relief, or one of the many marble finishes. Then for insulation, either foamed phenolic plastic or aerated concrete could be used.

The materials being developed by Cubitts are exciting, but perhaps even more important to the success of the Skinstone and relief mouldings, is the fact that Cubitts have a resident sculptress, Miss N. Keddie, who is using them for some intensely pleasing contemporary designs. Miss Keddie is well-known in Scotland where she has produced many works, mostly in association with architects and builders.

Cubitts felt that the development of relief decoration should be under the guidance of a sculptor: "The building," they say, "should be considered as a piece of sculpture as well as having its functional uses."

Work is now going ahead to develop a service for designers and architects to produce sculptured elevations to scale. By so doing, the effects of their designs may be assessed before erection on site. This seems a sound idea.

(Above) One of the many designs produced by Cubitts. It represents a fish.

(Left) The vacuum forming machine. Among the mouldings in the bottom left-hand corner is one with its original. Solid moulds must have vents through them for this operation.

Spray Pvc or Precoat?

In the USA, pvc-coated metal is well established, and consumption is estimated at 30 million sq. ft in 1959. But Metal and Thermit Corporation have recently announced a 100 per cent solids vinyl coating system called Unichrome Super 5300 which permits coatings up to 0·060 in thick to be sprayed in one operation.

In their launching campaign, the vice-president of the corporation took sides against precoated metal and listed these advantages for spray applied vinyl finishes:—

(1) No special care in handling metal during fabrication. Faster production is possible.

(2) Finish applied in fabricator's own shop using standard spray equipment.

(3) Rejects can be stripped of their vinyl finish chemically and then resprayed.

(4) Welding and forming operations are done prior to coating.

(5) Finish can be sprayed on complex shapes and castings, as well as flat surfaces.

(6) No raw or unfinished edges.

(7) To change colour, merely change the vinyl spray material. No unnecessary investment in inventory.

(8) Scrap metal is uncoated, keeping up its value. Waste of vinyl is eliminated.

It seems a bit odd that this firm should take sides against precoated metal since sprayed pvc films might well be used in their manufacture. Perhaps, however, with laminating capacity in the USA running over four times the consumption, the firm think it best to keep off the precoated metal market.

Polyethylene Properties Extended

Polyethylene was first made by ICI using a high pressure process. Subsequently, stronger grades were produced in low pressure processes over catalysts developed by Montecatini (Ziegler catalysts) and by Phillips Petroleum Company. High density polyethylene made by the Montecatini or Phillips processes may be mixed with low pressure polyethylene made by the ICI process to give intermediate density plastics. These are mixtures.

Even different properties may be obtained by copolymerisation of, say, ethylene with propylene when the long copolymer chains contain both sorts of molecule. British Resin Products are exploiting this copolymerisation process using Phillips catalysts, and have now announced three new grades of modified polyethylenes. These are designed for use in applications where better resistance to stress-cracking and greater load bearing properties (than can be produced in straight high density polyethylene) are required.

The new types are type 3, which has the best mechanical properties and resistance to stress cracking; type 12 which combines good processing qualities with good all-round physical properties, and type 40 which is an easy flow grade designed for injection moulding difficult items. Types 3 and 12 can be moulded round metal inserts, a factor of importance in injection moulding. Properties are outlined below.

Properties of Polyethylene Copolymers

	Type 3	Type 12	Type 40
Melt index	0·5	1·2	4·0
Density	0·95	0·95	0·95
Softening point, °C	115	115	115
Tensile strength, lb per sq. in	3,200	3,200	3,200
Elongation at break	300	200	150
Youngs Modulus, lb per sq. in	$1·2 \times 10^5$	$1·2 \times 10^5$	$1·2 \times 10^5$
Impact strength, ft-lb per in notch	10·0	3·5	2·0
Stress cracking, hr	300	100	18

Applications for type 3 include blown bottles, particularly where maximum stress-cracking resistance is required; blown film for boilable packs; cable insulation; monofilaments, where the best creep properties are wanted; and industrial mouldings calling for maximum impact strength and stress-cracking resistance.

British Resin Products Limited, Piccadilly, London, W1.

Acidity of Wood

Wood is in general slightly acidic, and it is known that certain species tend to accelerate the corrosion of iron fittings under damp conditions. Oak, sweet chestnut and western red cedar are well known for this effect. In working with them it is common practice to use galvanised nails and wooden dowels for fastenings rather than iron or steel nails and screws. Until recently, however, little was known about the corrosive behaviour of many less familiar timbers, including species imported in bulk since 1939. A newly published TDA report goes some way towards furnishing this information.

Corrosion of iron is, of course, a complex process involving many factors other than the acidity of the metal's environment. But it has been shown that, other conditions being equal, the acidity of a wood is likely to be significant as a corrosive influence. In "The Acidity of Wood," published by the TDA at 3*s* 6*d*, Dr. V. E. Gray evaluates the degree of acidity found in 146 hardwood timbers and 21 softwoods.

Tests for acidity were conducted on freshly prepared sawdust obtained from wood specimens of unknown age. In addition to the measurement of pH, the wood was tested for its ease of staining with iron and in the report the table listing the acidity of test specimens also indicates the degree of staining observed when a drop of 1 per cent ferric chloride was applied to the end grain surface of the samples.

The pH experiment showed considerable variation within a single species, and also that variation in some instances may be attributed to the effects of ageing. The experiment revealed, however, that a certain uniformity is exhibited by timbers of the same botanical family.

A correspondence between botanical family and staining with iron salts was found. Staining was less marked with softwoods as a class than with hardwoods. In no case was a stain on a softwood designated as dark, whereas 38 hardwood species developed a dark stain in contact with iron salts. There was found to be no significant relation between high acidity and dark staining.

Timber Development Association, 21 College Hill, London, EC4.

Neutron Shielding Material is Cast

A technique has been developed in the research division of High Duty Alloys for the production of new thermal neutron shielding materials with improved formability which will be known as the Hiduminium 400 series.

The product consists of boron carbide of suitably fine mesh size, evenly dispersed in a fully wrought aluminium matrix, clad on both sides with high purity aluminium. This material differs radically from conventional Boral which is produced by a powder metallurgy technique and is non-formable.

A method has been perfected by which the boron carbide particles can be uniformly suspended throughout molten aluminium, followed by semicontinuous casting to a rolling slab which is then clad and rolled in the normal manner. The boron carbide used has a purity better than 99 per cent and the concentration in the new material can be adjusted to suit customers' requirements, the maximum addition being 30 per cent boron carbide by weight.

The particle size can also be varied between 80 and 200 mesh but for maximum formability the coarser mesh sizes are preferred. The cladding, which is used primarily to protect the roll surfaces during fabrication, can be varied from a minimum of 5 per cent each side. Compared with conventional Boral, therefore, a much greater effective core thickness may be obtained.

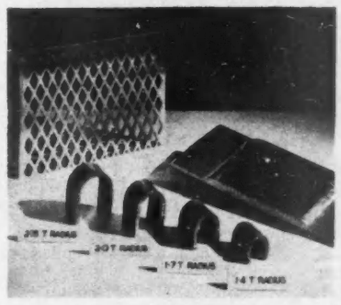
The plate or sheet is normally supplied in standard sizes either 72 in or 96 in long, by 36 in of 45 in wide, over a wide range of gauges. Lengths greater than these can be produced, however, for special applications. For example, at a total thickness of 0·180 in, a plate 180 in by 45 in can be supplied.

The new materials are useful in the atomic reactor industry because of their light weight, good corrosion resistance, good heat conductivity, stability up to the melting point of aluminium and the ability to absorb thermal neutrons without the production of hard gamma radiation.

Due to the conventional techniques of fabrication such as continuous casting and rolling, the price is substantially lower than that of Boral produced from sintered compacts. However, the prices will depend on the boron carbide content, the thickness and the quantity of sheet ordered.

Properties of Aluminium-Boron Carbide Sheet

Boron carbide content, per cent	Condition	Thickness, in	Ultimate tensile strength, tons per sq. in	Elongation, per cent
20	Annealed	0·25	4·2	11
20	Annealed	0·064	3·3	4
20	Annealed	0·025	2·9	3
15	Annealed	0·175	5·2	7



Bending and welding characteristics compare favourably with sintered Boral.

The increase in formability over conventional Boral is most marked. Sheet ¼ in thick containing 15 and 30 per cent boron carbide can easily be bent cold round radii of 3T and 6T respectively. Tubes and cylinders can be manufactured by bending the annealed sheet and seam welding the butted joint.

The thermal conductivity of shielding materials is important because of the dangers of overheating in the reactor. Typical thermal conductivity values for 15 per cent boron carbide material are approximately 320 Btu per sq. ft per hour per °F per in.

The makers suggest the following working practice. For drilling, use carbide tipped drills with slow speed and high feed pressures. Drilling is only recommended when holes cannot be reached with a punch. When punching, use a carbide tipped punch and a die of hardened tool steel. Punch and die must be kept sharp to maintain hole sizes.

The material can be sheared but shear blades must be kept sharp to ensure maintaining the tolerance. High speed taps are satisfactory, although they should not be too long since the boron carbide causes tap wear.

No serious problems are encountered during the welding of plate if the argon shielded tungsten arc method of welding is used. Commercially pure aluminium, and 5Si-aluminium filler rods can be used with equal success. It is recommended that where two plates are required to be welded together a strap type weld is used.

High Duty Alloys Limited, Slough, Buckinghamshire.

Plain Words

By Capricorn

We are too cock-sure of our scientific ability. Give us enough money and time, we say, and we can find the solution to almost any problem.

Maybe it is the writers and journalists who are to blame for this excessive confidence, because if you talk to a real man of science you invariably find that he is intellectually modest. It was for that reason that I warmed to the words used by Professor C. F. Powell when he gave the Kelvin Lecture to the Institution of Electrical Engineers recently. His subject was cosmic radiation. He talked in terms of 70,000 light-years and 100,000,000° Centigrade.

To end the lecture he quoted Bacon's words: "The universe is not to be narrowed down to the limits of the understanding, as has been man's practice up till now, but rather the understanding must be stretched and enlarged to take in the image of the universe as it is discovered." For people of his generation, Professor Powell said, this stretching and enlarging was a most painful process, but "the younger generation take to it like ducks to water."

An intelligent student can understand almost anything difficult and complex if he is well taught, but it is given to few of us to pioneer a new understanding. To attain to new comprehension, and to express it in terms that other men can accept and develop, is still a rare achievement, as it was in Bacon's day.

We of this generation, being spoilt with adequate equipment for research, are in danger of contracting a curious form of mental laziness. Because it is so easy to say let's do a statistical survey, or get an operational research man to come and look at the problem, we don't trouble to do some real thinking ourselves. We ought to let that greatest computer of all—the human mind—wrestle with the problem. We ought to feed it with data, facts, impressions, ideas, suggestions, aspirations—everything that the healthy mind lives on and thrives on, so that it has a chance to come up with a brilliant solution.

There is no substitute for hard thinking, whether it is for solving a problem which is usually solved by applying a hunch, or for the kind of problem which looks deceptively simple when we have amassed lots of statistics.

After the Kelvin Lecture, Professor Powell enjoyed some reminiscing with Sir Willis Jackson (President of the Institution), with Sir George Thomson and several distinguished engineers. Tales of the Cavendish Laboratory and Rutherford were told—of the difficulty of obtaining three screws or a piece of soda glass. Those were the days for hard thinking!

I hope we retain our creative ability now that we are more and more getting machines to do the thinking for us.

Letters to the Editor

Scottish Students Go South

SIR, With regard to your article "Engineering Growth on Clydeside" (ENGNG., 1 April '60, p. 446), I would like to throw further light on the graduate situation in Scotland. Scottish engineering students, unlike their English counterparts, have a five-month summer vacation which they are duty bound to spend on gaining industrial experience.

Every year, 40 per cent of the students available accept student employment from English firms rather than accept the paltry financial offers of the Scottish concerns: for example, first year, £3; second year, £4; third year, £5. Furthermore, the firms in the south offer a well-planned course in engineering practice and technique; whereas, their Scottish counterparts put you in a toolroom for five months and forget you.

When graduated, the student finds that, while English and American firms are willing to travel the length of the country to interview a graduate, Scottish companies prefer to wait for the graduate to apply for a position; and, whereas the English and American firms offer attractive salaries, and special help and consideration in the cases of the married man, the honours graduate and the specialist, the Scottish employer merely endeavours to make it plain that he is doing you a favour and then offers a miserable £500 per annum. Take it or leave it. Do you wonder there is emigration?

Yours faithfully,

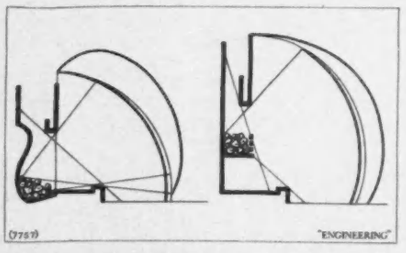
IAN GORDON.

382 Maryhill Road,
Glasgow, NW.
4 April, 1960.

Draughts in Rooms

SIR, I have read the recent letters on "No-Draught Fires" (ENGNG., 18 Mar. '60, p. 376) and would like to comment first on Mr. M. Jelley's contribution. It is not sufficient merely to arrange the fire near to the feet, that is, low down, but it is necessary that from the position of the feet a large arc of the fuel bed should be visible.

The accompanying diagrams represent centre sections through a well fire and a high-level openbar fire, respectively, and the radiation received from the visible surface of the fire beds at any point on a circular reference arc has been plotted, to an arbitrary scale to the outside of the arc, and the radiation received from the fire back, etc. (assumed to be at half the absolute temperature of the bright parts of the bed, and taking into account an estimate of relative surface areas) is plotted on the inside of the arc. The distance between the two curves gives the relative radiation intensity in any particular direction. Plainly, the low fire radiates mainly to the ceiling and nearby feet are in the shadow of the kerb, whereas a high fire sends the bulk of the radiation forward, and the shadow zone remains extremely narrow. (Note that flames radiate comparatively little heat.)



Radiation from a well fire and a high-level fire, respectively. The outer strong curve represents radiation through a point on the circular reference curve from the fire bed and the inner curve radiation from the fireback, etc. Assumptions made are: black body radiation; fire temperature, 1,200° K; fire-body temperature, 600° K. Only the limiting rays for either radiation are shown.

As far as the dust nuisance is concerned, which is supposed to be greater with high fires, that is not my experience, provided the Victorian ashpans and riddles have been kept in good repair. The messiest fires, I think, are the well fires, when it comes to actual ash removal as distinct from flicking cinders back.

May I also deal briefly with Mr. J. D. Depledge's contribution? Such vents as I am familiar with have an area which is small compared with the throat of a chimney, say from $\frac{1}{16}$ to $\frac{1}{4}$, and if the chimney air is substantially to be supplied through these ingenious devices the air velocity through the vents must be correspondingly high. That, however, requires a partial vacuum to be established (by the chimney gases) in the room, and the sealing of other air inlets has to be of a high order of perfection. A medium sized sitting room may have a total length of 300 ft of floorboard gap, 50 ft of gap below wainscoting 20 ft around a door and 50 ft around windows. If the total area of these gaps is to be kept to half of the vent area, gaps only 0·001 in wide on average would appear tolerable.

As far as the reputed pool of cold air on the floor level is concerned I simply have never experienced one. It is very rare to observe stratified air in any living room during the heating season. Once the room is warmer than the outside air the circulations set up by air which is cooled on windows and outside walls makes stratification impossible. Air in a room which is heated by an open fire with flue can only be heated by contact with objects already heated by radiation. My guess is that what Mr. Depledge believes to be a stagnant pool of cold air at floor level is, in fact, fresh air drawn in from between floorboards and from under the doors.

Yours faithfully,

O. KANTOROWICZ.

4 Beverley Terrace,
Cullercoats, North Shields.
2 April, 1960.

Plastic Coated Steel Sheet

SIR, As pioneers in the manufacture of plastic coated steel in this country, we naturally read with great interest your article headed "Promising Precoated Strip is a Teaser" (ENGNG., 18 Mar. '60, p 374). In our view the article does not present an entirely accurate picture of the use of plastic coated steel sheet by industry.

As with all new materials, problems were obviously encountered initially, but as a result of intensive research and development work the majority of problems have been successfully overcome. The material has, hence, been accepted as a production material and is in full scale use for motor-car facia panels, washing machines and spin dryers, water heaters, occasional furniture, partitioning, and so on. These are now established uses where full advantage has been taken of the unique properties of the material,

We suggest that plastic coated steel users should observe the following points:

(1) Design the component with the material in mind.

(2) Adopt the special techniques which have now been fully developed for large scale production.

(3) When in doubt consult the technical staff of the supplier, particularly in the early stages.

We are confident that a bright future exists for plastic coated steel, and we look forward to its increasing use for numerous applications.

It may also be interesting for your readers to know that in Belgium the use of the plastic coated sheet is going ahead extremely rapidly and there are now already in existence a number

of applications in the architectural field, both for external and internal use, in Brussels and Liége. In fact, the whole of the new Postal Sorting Offices in Brussels, and these, by the way, are probably the most modern in the world, have ceilings of the acoustic type made from plastic coated metal.

Yours faithfully,
F. H. SMITH,
London Manager.

John Summers and Sons Limited,
St. Ermin's, Caxton Street,
London, SW1.
4 April, 1960.

Redress for Awkward Loads

SIR, Mr. M. J. Macfarlane's letter (ENGNG., 1 April, '60, p. 440) compels me to write again, because the obstruction of roads demands serious thought and because I so admire champions of lost causes. Should someone be lucky enough to have the time and ability he could quite profitably spend it in writing a book entitled *The Social and Economic Aspects of Internal Transport in Great Britain.*

I have been accused of bias against the private motorist. On the contrary, I develop the usual temperature when my lawful movement is impeded. My feelings are hurt most, however, when the cause of the obstruction is a conglomeration of quite normal vehicles and the base cause is a multiplicity of fellow motorists. The indivisible or abnormal load is but an infinitesimally small proportion of the total loads of goods and humans on the roads. Moreover, I have passed at speed and in comfort many an indivisible load when, five miles back or five miles further on, I would not have been able to do so. I have yet to see the indivisible load that can create chaos on a four-lane roadway. It is the two-lane roadway that pin-points the whole problem of impeded movement today.

One must be fair to these awkward loads. They can, by reason of bridge capacity and turning circles, be found only on certain routes. One may travel widely and never meet one. I have not yet encountered any fractionating columns in Cornwall but I have crawled into that delightful county in Indian file, hours late, exhausted and potentially neurotic. The directorate of one of our largest automobile producers is planning on the basis of 13 million vehicles on the roads within the next three years. The Government is to introduce traffic wardens and there is talk of privilege access to restricted city areas for certain people only. In 1914, the total of mechanically-propelled vehicles on the roads was 388,860, while in 1939, the total had reached 3,148,000. I ask that one tries to assimilate what 13 million vehicles will mean. It appears that soon no one will worry about being held up by awkward loads. If the expansion of the mechanically-propelled vehicle continues and the road programmes still lag behind, one can see no hope, unless cars are later designed to run perpendicularly on their rear fenders!

The railways have died the natural death which arises from failure to meet the customers' demands: convenience and cost. I recall one small country station where, in the 1920's, no fewer than 20 mixed wagons per week arrived and left at the service of the local farming community. Today, this station is dead and is shortly to be officially buried. The lime now comes by road and is spread by the same vehicle that loaded it at the works. Fertilisers, seeds and other farming needs arrive at the field or at the barn. This is cheaper for the farmer and certainly more convenient. No longer—perhaps to the advantage of the motorist—does he take his farm vehicles to the station to collect his goods or to load them for despatch. This is the common pattern throughout the country today. It means loss of revenue for many spur lines and their eventual death through economic decay.

Mr. Macfarlane would like to see a canal system able to remove much of the non-human load from the roads. He even claims to be willing to move a load 50 times greater than the limiting 300 tons of the more efficient turbo-alternators. On a canal this would require a bottom able to carry 15,000 tons deadweight. This, of course, would mean a ship canal comparable in dimensions, if not even greater, than the Manchester Ship Canal. It would be ridiculous to visualise an indivisible load of this weight but even if the cargo were composed of small units the 15,000 tons deadweight would still require a canal suitable for ocean-going vessels. Turbo-alternators have a habit of debouching from the manufacturers' premises at infrequent intervals and journeying to quite remote and countrified sites. Eight or so deliveries to such a destination would hardly merit the construction of such a waterway branch. If the load required collecting at some intermediate point the problem of road haulage would not have been solved.

The stories of the canal builders show that the problem of water for locking replenishment was not as simple as one might think even in their day, and should it be feasible to build such a canal system to service the requisite areas of the country it is doubtful whether sufficient water would be available to maintain it. A problem rapidly assuming the same proportions as that of the traffic density is that of the national shortage of water, as was very evident last year.

A road system will always be cheaper and easier to construct than a canal system; it is impossible to form a slope with water and a canal of the capacity visualised by Mr. Macfarlane would require lock systems of magnitude. To reinstate and modernise our existing canals to enable them to cope with the weight of today's traffic would require a financial programme not much short of that demanded by the railway modernisation programme. Had this been possible, it would, of course, have been done as a function of the nationalised transport system.

The answer to all these problems is without doubt the construction of roads suitable for the conditions now ruling. Even if the awkward load disappears, through a drop in exports or satisfaction of home demand, the question of 13 million vehicles will still have to be met. It is almost openly agreed in Government circles that the existence of the railways must be a charge on the public, whether they use them or not. The possibility of reducing road traffic and at the same time helping the finances of the railways by forcing, through statute and taxation, the use of the railways instead of the roads is political dynamite of such power that no government could use it and expect to live.

Yours faithfully,
DUDLEY A. BAKER.

47 Ashley Road,
Altrincham, Cheshire.
2 April, 1960.

Preventing Fretting Corrosion

SIR, I have read with interest the article on "Greases to Prevent Fretting Corrosion," by N. A. Scarlett (ENGNG., 25 Mar. '60, p. 424).

The problem of fretting corrosion is almost as old as engineering itself, and even today, no complete procedure for its elimination is available. In the now classic paper on the subject, "An Investigation of the Fretting Corrosion of Closely Fitting Surfaces," by G. A. Tomlinson, P. L. Thorpe and H. J. Gough (*Proc.*, I.Mech.E., vol. 141, p. 223 (1939), the authors gave details of tests using many combinations of metals—and even non-metals—but found that in no case was fretting absent. The conclusion reached was that combinations in which nickel formed one surface, gave rise to the least corrosion.

Since publication of that paper, this fact has been put to a great deal of practical use. Fretting corrosion has been considerably reduced by electro-depositing the surface of one component with nickel, prior to fitting. The situations have ranged from small ball race seatings to large taper fittings, with satisfactory results.

So far as lubricants are concerned, Tomlinson *et al* reached the conclusion that these modified the phenomenon, but did not prevent it. However, since then there have been many advances in lubrication technology and it may well be that this conclusion is no longer valid. It would, however, have been of interest if tests had been carried out using nickel as one surface to determine whether such combinations could be further improved by the use of modern lubricants.

Yours faithfully,
J. W. OSWALD,
Chief Chemist.

Fescol Limited,
North Road, London, N7.
4 April, 1960.

Unified Screw Threads

SIR, Were the references to American United Standard Threads (ENGNG., 1 April '60, p. 437) made with an eye on the date; or perhaps Whitworth and United Standard are the names of two Australian football clubs yet to do battle?

Seriously, Sir, I am appalled that at this date there should be an article in one of our leading technical journals which talks about American United Standard Threads. Even if you had used the proper word, Unified, it would still be wrong. Unified Screw Threads, the subject of BS 1580, are the same the world over; they are being adopted by an increasing number of go-ahead firms, and have been the standard for Services' use for many years.

After all, it is now thirteen years since the Declaration of Accord between the United States, Canada and ourselves to use Unified Screw Threads, so surely the name should be fairly widely known by now.

Yours faithfully,
CHRISTOPHER BELL.

58 Kevington Drive,
Chislehurst, Kent.
5 April, 1960.

Editor's note.—We, too, were appalled and we apologise to readers. We must have referred, correctly, to Unified Screw Threads many times during each of the thirteen years since the declaration to which Mr. Bell refers.

Information by Television

SIR, I would like to thank Mr. T. Brimelow and Mr. L. L. Ardern (ENGNG., 1 April '60, p. 441, and 8 April '60, p. 472) for trying to put me on the right road with regard to CCTV in libraries. I feel that this involves two schools of thought. Is the library there to be used by the user or is it there as a personal fund of knowledge from which the librarian dishes out the rations?

Some librarians, I suppose, like to spoon-feed their clients while some lead them gently by the hand until they are mature enough to find out for themselves. CCTV strikes me as being part of the spoon-feeding process which I regard as a bad thing. Mr. Ardern compares it to the telephone, but CCTV must inevitably be a further step.

The actual use of and handling of books is a satisfying and civilising process and anything that tends to make this process a thing of the past is, I consider, to be deplored. CCTV, too, shows all the signs of being yet another rod for a back already well belaboured.

I have mentioned the approach of CCTV and people have noticed the mention. I feel I have done my duty. In passing, it is kind of Mr. Brimelow to say I am a little facetious at times. I have looked up the definition of this in the *Shorter Oxford English Dictionary* (I do not know on what channel you will get this work) and feel slightly flattered.

Yours faithfully,
FRANK H. SMITH.

8 April, 1960.

Plastics in 1961

AN INCREASE to more than 300,000 sq. ft of exhibition space has been reserved at Olympia, London, for the next International Plastics Exhibition and Convention, which will take place there between Wednesday, 21 June, and Saturday, 1 July, 1961.

The exhibition, which is to be known as INTERPLAS 61, is the sixth of the series being organised by the Iliffe journal *British Plastics* and is planned to cover all aspects of the industry, ranging from basic materials, semi-processed materials and finished products to industrial components, processing machinery and accessories. Any firms, whatever their country of origin, may exhibit their products at this exhibition. The last International Plastics Exhibition was held in June, 1959.

Further details may be obtained from the organiser, Mr. John L. Wood, Dorset House, Stamford Street, London, SE1, or by telephoning WATerloo 3333.

Exhibitions and Conferences

Railroad Conference.—Wed. and Thurs., 20 and 21 April, at the Penn-Sheraton Hotel, Pittsburgh, Penn., USA. Organised by the American Institute of Electrical Engineers; and the American Society of Mechanical Engineers, 29 West 39th Street, New York 18, USA.

Swiss Industries Fair.—Sat., 23 April, to Tues., 3 May, at Basle. Apply to the Commercial Attaché, Swiss Embassy, 18 Montagu Place, Brynston Square, London, W1. Tel. PADdington 0701

Computer Systems-Analyst, Special Six-Weeks Course.—Mon., 25 April, to Fri., 3 June, at 12 Grosvenor Place, London, SW1. Theme: "Management Practice and the Systems-Analyst." Organised by Production-Engineering Ltd., 12 Grosvenor Place, London, SW1 (Tel. BELgravia 3311). Inquiries to Courses secretary, Management Training (PE) Ltd., Park House, Wick Road, Egham, Surrey.

BACIE Spring Conference.—Wed., 27 April (11 a.m. to 4.15 p.m.), at the Federation of British Industries, 21 Tothill Street, London, SW1. Theme: "The Implications of the Crowther Report." Tickets £3 13s. 6d. Organised by the British Association for Commercial and Industrial Education, 26a Buckingham Palace Road, London, SW1. Tel. TATe Gallery 4985.

Iron Ores, Conference on Methods of Reducing.—Tues., 3 May, to Thurs., 5 May, in the Lasalle Hotel, Chicago. Organised by the Electrothermics and Metallurgy Division of the Electrochemicals Society. Further details may be obtained from Mr. R. R. Rogers, Mines Branch, Department of Mines and Technical Surveys, 552 Booth Street, Ottawa, Ontario, Canada.

Castings Congress and Exposition.—Mon., 9 May, to Fri., 13 May, in Philadelphia. Organised by the American Foundrymen's Society, Golf and Wolf Roads, Des Plaines, Ill., USA.

Illuminating Engineering Society's Summer Meeting.—Sun., 15 May, to Wed., 18 May, at Harrogate. Offices of the Society: 32 Victoria Street, London, SW1. Tel. ABBey 5215.

Business Efficiency Exhibition, 47th National.—Mon., 16 May, to Sat., 21 May, at Bingley Hall, Birmingham. Organised by the Office Appliances and Business Equipment Trades Association, 64 Cannon Street, London, EC4. Tel. CENtral 7771.

Public Works and Building Material, Second International Exhibition.—Thurs., 19 May, to Sun., 29 May, at Le Bourget Airport, Paris. Apply to the Société Expomat, 1 Avenue Niel, Paris, 17e.

Institution of Professional Civil Servants, Annual Delegate Conference.—Mon., 23 May, to Wed., 25 May, at the Winter Garden, Eastbourne. Institution's offices: Queen Anne's Chambers, 28 Broadway, London, SW1. Tel. WHItehall 0436.

Sheet Metal Shaping and the Testing of Sheet, Colloquium.—Mon., 23 May, to Wed., 25 May, at 2 Rue de Presbourg, Paris, 8e. Organised jointly by the International Deep Drawing Research Group; and the Société Française de Métallurgie, 25 Rue de Clichy, Paris, 9e.

Electronic Forum for Industry, Conference.—Tues., 24 May, to Thurs., 26 May, at Olympia, London, W14. Apply to the honorary secretary, EFFI, c/o the Electronic Engineering Association, 11 Green Street, London, W1. Tel. MAYfair 7874.

National Engineering Laboratory, Open Days.—Wed. and Thurs., 15 and 16 June. Applications, stating which day preferred, should be sent to the Director, National Engineering Laboratory, East Kilbride, Glasgow.

Meetings and Papers

British Computer Society

LONDON
"Automation and Uncertainty," by Stafford Beer. Northampton College of Advanced Technology, St. John Street, EC1. Thurs., 21 April, 2.30 p.m.

British Institution of Radio Engineers

LONDON
"Electronics in Oceanography," by M. J. Tucker. London School of Hygiene and Tropical Medicine, Keppel Street, WC1. Wed., 27 April, 6.30 p.m.*

British Interplanetary Society

LONDON
"High-Altitude Chambers and Pressure Suits," by Dr. E. W. Still. Hoare Memorial Hall, Church House, Great Smith Street, SW1. Thurs., 28 April, 7 p.m. (Tickets required.)

Chemical Society

ST. ANDREWS
"Are Scientists Literate?" by Mr. John Maddox. St. Andrews and Dundee Branch. Chemistry Department, St. Salvators College, St. Andrews. Fri., 22 April, 5.15 p.m.

Illuminating Engineering Society

LEICESTER
Annual General Meeting, and Open Discussion. Leicester Centre. Demonstration Theatre, East Midlands Electricity Board, Charles Street, Leicester. Mon., 25 April, 7 p.m.

Institute of Fuel

NOTTINGHAM
"Nuclear Power: The New Power Stations," by G. T. Shepherd. East Midland Section. Showrooms of the East Midlands Gas Board, Nottingham. Thurs., 28 April, 6.15 p.m.

Institute of Metals

LONDON
"Deformation and Fracture of Ionic Crystals," by Dr. J. Washburn, Associate Professor of Metallurgy in the University of California. Wed., 27 April, 6.30 p.m.

Institute of Physics

BIRMINGHAM
Annual General Meeting. Education Group. The University, Birmingham. Thurs., 21 April, 5 p.m.

MIDDLESBROUGH
"Jodrell Bank Telescope," by Mr. H. A. Prime. North Eastern Branch. Cleveland Scientific and Technical Institute, Middlesbrough. Thurs., 21 April, 6.30 p.m.

Institute of Welding

LONDON
Annual General Meeting. North London Branch. Wed., 20 April, 7.30 p.m.

Institute of Wood Science

LONDON
"Sub-Microscopic Structure of Wood: A Summary of Our Present Knowledge," by Professor R. D. Preston. Imperial College, Exhibition Road, South Kensington, SW7. Wed., 27 April, 6.45 p.m.*

Institution of Civil Engineers

LONDON
"Design, Fabrication and Erection of the Ganga Bridge," by S. G. Savarkar, S. Turley, J. Williams and R. J. C. Tweed. Tues., 26 April, 5.30 p.m.*

Institution of Electrical Engineers

LONDON
"Broadening University Courses." Discussion, opened by Professor H. E. M. Barlow. Education Discussion Circle. Fri., 22 April, 6 p.m.*
"An Experimental Transistor-Controlled Component Selection and Testing Machine," by T. C. Cardwell, J. R. W. Smith and G. H. King. Measurement and Control Section. Tues., 26 April, 5.30 p.m.*
"A Survey of Microwave Techniques for the Transmission of Speech and Vision," by K. C. Kao. London Graduate and Student Section. Mon., 25 April, 6.30 p.m.*

EDINBURGH
"Application of Irradiation in Industry," by M. C. Crowley-Milling. South East Scotland Subcentre. Carlton Hotel, North Bridge, Edinburgh. Tues., 19 April, 7 p.m.

FARNBOROUGH
"Machine Translation of Languages," by Dr. A. D. Booth. Southern Centre. Farnborough Technical College, Boundary Road, Farnborough, Hants. Wed., 20 April, 6.15 p.m.

GLASGOW
"Some Considerations in the Application of Power Rectifiers and Convertors," by J. P. McBreen. South West Scotland Subcentre. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank Crescent, Glasgow, C2. Wed., 20 April, 6 p.m.

Institution of Engineering Designers

BRADFORD
Films: "One Thousand Miles in 14 Hours" and "From Strength to Strength." Yorkshire Branch. Midland Hotel, Bradford. Wed., 27 April, 7.30 p.m.

Institution of Heating and Ventilating Engineers

GLASGOW
"High-Velocity Air Systems," by E. F. W. Cowell. Annual General Meeting. Scottish Branch. Scottish Building Centre, 425 Sauchiehall Street, Glasgow, C2. Tues., 26 April, 6.45 p.m.

LIVERPOOL
Annual General Meeting. Liverpool Branch. Exchange Hotel, Tithebarn Street, Liverpool. Fri., 22 April, 6.30 p.m.

Institution of Locomotive Engineers

LONDON
"Steel Wheels and Tyres," by C. F. Ryan and Dr. B. B. Hundy. Institution of Mechanical Engineers, 1 Birdcage Walk, St. James's Park, SW1. Tues., 26 April, 5.30 p.m.*

Institution of Mechanical Engineers

LONDON
"A Comparison of Anglo-American Productivity Figures." Discussion. Industrial Administration and Engineering Production Group. Mon., 25 April, 6 p.m.*

BIRMINGHAM
"Future of Air-Breathing Engines in Aviation," by S. G. Hooker. Repetition of James Clayton Lecture. Midland Branch. Matthew Boulton Technical College, Suffolk Street, Birmingham. Thurs., 21 April, 6 p.m.*

BRISTOL
"Vertical Take-Off," by D. Keith-Lucas. Western Branch. Bristol University Engineering Laboratories, University Walk, Bristol. Thurs., 28 April, 7 p.m.*

Institution of Mining and Metallurgy

LONDON
"Production of Thorium Metal," by A. R. Gibson; and "Genesis of Marine Sedimentary Iron Ores," by Professor H. Borchert. Geological Society, Burlington House, Piccadilly, W1. Thurs., 21 April, 5 p.m.*

Institution of Plant Engineers

BLACKBURN
"Modern Electric Space Heating," by W. N. Shires. Blackburn Branch. Castle Hotel, Blackburn. Thurs., 21 April, 7.30 p.m.

DARTFORD
"Ferrous and Non-Ferrous Welding": Discussion. Kent Branch. Railway Hotel, Dartford. Wed., 20 April, 7 p.m.

LEEDS
"The Yorkshire Motorway," by J. Michie. West and East Yorkshire Branch. Houldsworth School of Applied Science, The University, Leeds. Mon., 25 April, 7.30 p.m.

Institution of Production Engineers

LONDON
"Modern Planning and Progress in the Building Contracting Industry," by R. S. Smith. South Eastern Region. Royal Commonwealth Society, Northumberland Avenue, WC2. Thurs., 21 April, 7.30 p.m.

BIRMINGHAM
"Meeting a Challenge," by J. Silver. Birmingham Section. James Watt Memorial Institute, Great Charles Street, Birmingham. Wed., 20 April, 7 p.m.

DERBY
"The Production Engineer in a Changing Economy": Discussion. Regional One-Day Conference. Welfare Hall, Rolls-Royce Ltd., Derby. Sat., 23 April, 9.30 a.m.

OXFORD
"Power Factor Correction of Industrial Electricity Supplies," by R. O. M. Powell. Oxford Section. Town Hall, Oxford. Tues., 19 April, 7.30 p.m.

PETERBOROUGH
"Radio Isotopes in Engineering," by W. D. Busbridge. Peterborough Section. Peterscourt, Peterborough. Wed., 20 April, 7.30 p.m.

Royal Aeronautical Society

LONDON
"On Reducing Costs of Space Research," by J. E. Allen, Astronautics and Guided Flight Section. Institution of Mechanical Engineers, 1 Birdcage Walk, St. James's Park, SW1. Thurs., 21 April, 6 p.m.*
"Pilot Training": Discussion. Agricultural Aviation Group. Fri., 22 April, 7 p.m.

Society of Chemical Industry

LONDON
"Electrode Processes in Primary Batteries," by D. H. Collins. Annual General Meeting. Thurs., 21 April, 6 p.m.

Society of Instrument Technology

CHELTENHAM
Annual General Meeting and Presidential Address. Cheltenham Section. Belle Vue Hotel, Cheltenham. Wed., 20 April, 7.30 p.m.

LOUGHBOROUGH
Annual General Meeting and Presidential Address. East Midland Section. College of Further Education, Greenclose Lane, Loughborough. Thurs., 21 April, 7.15 p.m.*

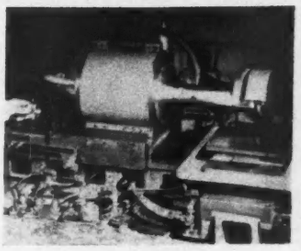
NEWCASTLE UPON TYNE
"Gas Calorimetry," by A. D. E. Lauchlan. Newcastle Section. Roadway House, Oxford Street, Newcastle upon Tyne. Wed., 20 April, 7 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. An asterisk (*) is placed where it is understood that refreshments are available prior to the time stated.

British Computer Society, Finsbury Court, Finsbury Pavement, London, EC2. (MONarch 6252)
British Institution of Radio Engineers, 9 Bedford Square, London, WC1. (MUSeum 1901)
British Interplanetary Society, 12 Bessborough Gardens, London, SW1. (TATe Gallery 9371)
Chemical Society, Burlington House, Piccadilly, London, W1. (REGent 0675)
Illuminating Engineering Society, 32 Victoria Street, London, SW1. (ABBey 5215)
Institute of Fuel, 18 Devonshire Street, Portland Place, London, W1. (LANgham 7124)
Institute of Metals, 17 Belgrave Square, London, SW1. (BELgravia 3291)
Institute of Physics, 47 Belgrave Square, London, SW1. (BELgravia 6111)
Institute of Welding, 54 Princes Gate, Exhibition Road, London, SW7. (KNIghtsbridge 8556)
Institute of Wood Science, 21 College Hill, London, EC4.
Institution of Civil Engineers, Great George Street, London, SW1. (WHItehall 4577)
Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London, WC2. (COVent Garden 1871)
Institution of Engineering Designers, 38 Portland Place, London, W1. (LANgham 8847)
Institution of Heating and Ventilating Engineers, 49 Cadogan Square, London, SW1. (SLOane 3158)
Institution of Locomotive Engineers, 28 Victoria Street, London, SW1. (ABBey 6672)
Institution of Mechanical Engineers, 1 Birdcage Walk, St. James's Park, London, SW1. (WHItehall 7476)
Institution of Mining and Metallurgy, 44 Portland Place, London, W1. (LANgham 3802)
Institution of Plant Engineers, 2 Grosvenor Gardens, London, SW1. (SLOane 0469)
Institution of Production Engineers, 10 Chesterfield Street, London, W1. (GROsvenor 5254)
Royal Aeronautical Society, 4 Hamilton Place, London, W1. (GROsvenor 3515)
Society of Chemical Industry, 14 Belgrave Square, London, SW1. (BELgravia 3681)
Society of Instrument Technology, 20 Queen Anne Street, London, W1. (LANgham 4251)

CRYSTAL CUTTER

Automatic Indexing



Now available is a machine for cutting semiconductor crystals and slices, as well as glass tubes for glass to copper seals.

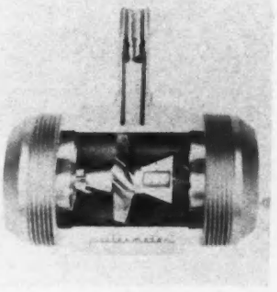
The machine is operated hydropneumatically and is designed to cut at steplessly variable feed rates. The range is from 10 in to 1,000 in per hour. The design includes provision for automatic indexing to cut parallel lines and the pitch is also steplessly variable by means of a micrometer adjustment. Slices can be made at widths from zero to 1 in. The repetitive accuracy of indexing for these parallel cuts is of the order of ± 0·001 in.

The cutter blade consists of a diamond impregnated or bonded wheel and the high speed spindle unit driving it may be designed for single or two-speed operation and for single or multiple cutting discs, varying from 6 in to 4 in diameter. The power available from the generator unit is 2 kW.

The machine illustrated will clear work to about 1¼ in above the root of the cutting groove. The vertical adjustment is 1 in. Cutter widths vary from about 0·012 in upwards. The work may be attached to steel plates for mounting on a magnetic chuck or on plates arranged for pneumatic clamping. The work is waxed on to glass plates or attached by synthetic resins. The adjustments for pitch indexing, the traversing rate of work under the cutter, and the flow of coolant are all inside the cowl. The other controls are arranged externally. A Perspex cover prevents loss of the Honilo coolant used to prevent sludge settling on the machine slides. *Salford Electrical Instruments Limited, Silk Street, Salford 3, Lancashire.*

FLOW METER

Induced Signal by Free Rotor



Now being made in this country is the Pottermeter flow meter which has an accuracy of better than 0·5 per cent over a range of flow rates of 20 to 1, and a reproducibility of better than 0·1 per cent.

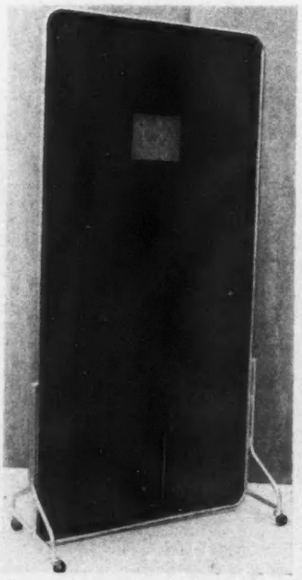
The meter fits in the pipeline requiring no more space than a normal T piece, and being no greater in diameter. It consists of a rotor running in guides rather than bearings and containing a magnet. The moving field set up when the rotor spins is used to energise a coil mounted on the outside of the pipe and not in contact with the liquid. The pulses are amplified, shaped and counted on a digital counter of some standard form with a time comparator if the rate of flow is required.

A wide range of sizes is made, from models with rotors ⅛ in diameter to 22 in diameter. The corresponding range of flows is from 0·1 to 40,000 gallons per minute. Larger sizes can be made to order. The meter can be used over the very wide temperature range from − 455° F to + 1,500° F and on liquids as varied as liquid oxygen and tar.

A unique feature is the fact that when running there is no end thrust. This is achieved by utilising the characteristics of the Venturi where the static pressure is greater below the expanded section than above it. This increase in pressure is balanced against the force of the liquid to keep the rotor running centrally. *De Havilland Propellers Limited, Hatfield, Hertfordshire.*

PROTECTIVE SCREEN

For Radiation



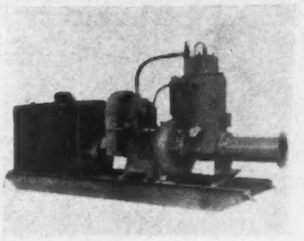
A light strong and fully mobile protective screen is now on the market for general industrial use.

The single unit measures 3 ft wide and stands 6 ft high. The lead glass window is 9 in by 6 in. The supporting frame is of welded steel tube carried on ball bearing castors. The screen itself is of resin bonded plywood and lead sheet. Window and screen give the same degree of protection, but different thicknesses are available for use with different intensities of radiation.

In addition to the single screen illustrated, a combination screen of three leaves is made. Each leaf is as described for the single type but the window can be omitted from the outer two if desired. Lead overlap covers the joints so that the protected area is 9 ft wide by 6 ft high. To meet scattered overhead radiation a folding top leaf can be added. A mirror viewing system can also be fitted. *Premise Engineering Company, The Crescent, Abbots Langley, Watford, Hertfordshire.*

CENTRIFUGAL PUMP

Rapid Priming



The latest addition to the Univac range of centrifugal pumps is a model that will deliver 3,500 g.p.m. against a total head of 32 ft.

Chief claims for the 12 in model are that it is virtually unchokeable and that the priming is extremely rapid. A separate vacuum pump is used to extract any air entrained in the pump body allowing the volute and impeller to be designed purely for pumping duty. The major components are therefore a vacuum pump mounted for direct drive from the engine shaft, the Univac self-priming equipment mounted on the suction side of the pump; the pump itself and a reflux box on the delivery side of the pump.

The vacuum pump is a twin cylinder horizontal air cooled unit. The priming equipment consists of two tanks, the first of which traps any air drawn in the pump suction and the second prevents any water entering the vacuum pump. The reflux chamber prevents air being drawn into the pump during priming.

Other items fitted include a trip to govern the water level in the first tank; an air cock to enable the vacuum to be broken while the pump is running so giving a rapid reverse flow down the suction to clear a blocked pipe; and an auxiliary snift valve for use when operating on low lifts and deliveries.

The pump will handle sludges up to 60 per cent solids content. The head characteristics are almost flat over the operating range, and fall continuously from zero output. The pump can operate where large volumes of air are encountered and also handle large volumes of water. *Henry Sykes Limited, 53b Southwark Street, London, SE1.*

MULTIPOINT SCANNER

Up to 12 Stations

A new multi-point scanner is now being made which has provision for monitoring the temperatures of up to 12 stations.

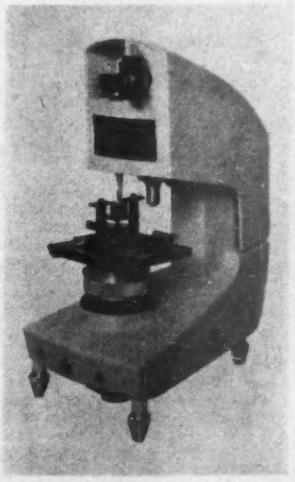
The instrument is designed for automatic continuous operation and has a standard moving coil millivoltmeter with a 5 in scale. Sensing is by means of thermocouples or resistance bulbs according to the temperatures involved. The former method is usually employed for temperatures above 200° C and the latter for those below. Thermopile sensing can also be used.

There can be two types of action. A single maximum temperature can be preset on the scale and if the temperature of any point being scanned reaches this value, scanning stops and an alarm or trip is put into operation. Alternatively, two settings can be made, the lower to sound an alarm and the higher to trip out the circuit. There is also provision for manual scanning of the points and also a visual indication of the station.

Relaying between the points and the instrument is by mercury switches and each station is connected in turn by means of these switches operated by a cam driven from a synchronous electric motor. Once a setting has been made the knob can be withdrawn to prevent unauthorised alteration. *West Instrument Limited, 51 Regent Street, Brighton 1.*

MICROHARDNESS TESTER

Semi-automatic Action



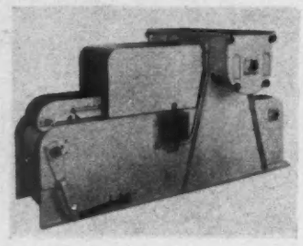
The model LL Tukon microhardness tester is semi automatic in operation and has a range of indentation loads.

The instrument is built for general use and has a vertical capacity of 2½ in. The load range is from 25 to 1,000 gm in 12 increments by adding dead weights. Observation is made through a Bausch and Lomb microscope with a dry objective of ×14 to locate test spots and a ×40 par-focalled dry objective for measurement. The operator does not have to touch the instrument during the test cycle, as the removal of the load is automatic. A 90° inclined angle eyepiece is used to reduce fatigue by giving more comfortable operation.

The LL is fitted with both the Knoop and the 136° diamond indentors. When set up the test is started by pushing a button and operation is indicated by a warning light. The load application time can be varied from 3 to 30 seconds. A precision mechanical stage is employed with accurate traverses in two directions. Controls are below the stage away from the working area. *George H. Alexander Machinery Limited, 82 Coleshill Street, Birmingham 4.*

FEED WEIGHER

With Bunker Agitator



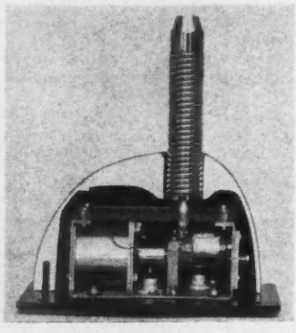
Now on the market is a machine that will store, weigh, and feed out difficult-to-handle materials.

Such materials as wood shavings, soft brown sugar, and damp granulate products can be placed in the bunker which has an internal slow running agitator. This keeps the material free within the bunker and prevents any tendency to bridge. A small volume of the material is delivered through an opening in the side of the bunker and the same total amount is always present within a container at the side of the bunker. By this means the density of the material available is not likely to alter due to variation in the amount present in the main bunker.

The feed mechanism is a belt that draws a layer of the material forward. Instead of a fixed gate, there is a rotary trimmer which prevents any build up and ensures that the layer brought forward is an even thickness. The belt can be fitted with a weighing mechanism and by the use of a feed back system giving signals to a controlling device, the height of the trimmer can be adjusted and therefore the thickness of the layer on the belt. Thus the weight of material delivered can be kept constant to within close limits, independently of variations of density in the bunker that may occur during the run. The degree of accuracy is dependent on the material being handled but even with materials as different as wood chips and castor sugar, the accuracy is within 1 per cent. Machines are available with various sizes of bunker and various widths of belt to cover a wide range of requirements. *Wm. Gardner and Sons (Gloucester) Limited, Bristol Road, Gloucester.*

TUNED AERIAL

For VHF Sets



The aerial unit illustrated was developed for use with VHF two-way radio sets for vehicles.

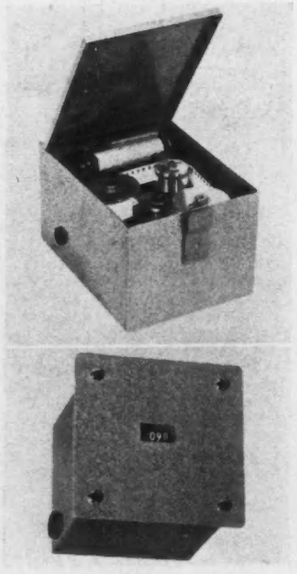
Very high efficiency is claimed as the unit is provided with automatic tuning for both the transmit and receive frequencies. Thus optimum operating conditions are obtained for each. The sets for which it was originally developed work in the 80 to 100 Mc/s band and have a frequency difference between the transmit and receive channels of the order of 10 to 12 Mc/s.

The Mobil-Antenna comprises a flexible and spring base type whip aerial mounted on a tuning unit. The latter incorporates trimming condensers and a coil, the inductance of which is changed by a solenoid operated dust core and provides for any two frequencies within the band. Spacing can be up to 15 Mc/s. No contacts are used in the switching and the solenoid is energised from the radio equipment when the "Press-to-Speak" button is operated.

The whole assembly is very rigid and is built to withstand the vibrations encountered in mobile and particularly motor cycle work. The tuning unit, which is built on an anodised aluminium base plate, is protected by a glass fibre moulding. Models are available for operation on 6, 12, and 24 V as well as for other frequency bands between 30 and 174 Mc/s. Other models are being developed. *Aveley Electric Limited, Ayron Road, Aveley Industrial Estate, South Ockendon, Essex.*

EVENT RECORDER

For Time Study



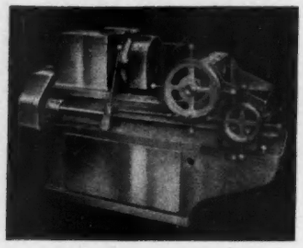
The recorder and hour meter illustrated will record the switching on and off of electrical apparatus and the period of time for which it operates.

The drive for the recorder is a 15 day clock movement with an accuracy of ± 5 minutes over the full cycle. This movement drives the recording chart at a speed of 1 in per hour. The chart is made of a copper sensitive Chromograph paper, 31 ft long and ⅝ in wide, with one edge perforated for the drive. Calibration is according to requirements. Quick replacement spools are used.

The stylus is of durable copper and is mounted on the armature of a solenoid normally rated for 200V d.c. 5 mA. A second stylus and solenoid can be fitted if desired and the chart can be run at other speeds. Alternatively, a sapphire stylus and a synchronous motor are available. The hour meter summates the running time; either a four or five digit counter can be fitted. *AEI Radio and Electronics Division, 155 Charing Cross Road, London, WC2.*

THREADING MACHINE

Tangential Diehead



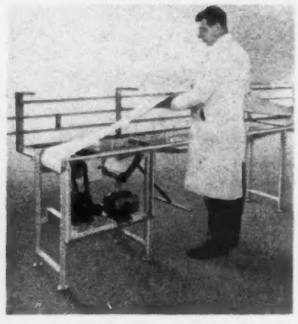
Two redesigned threading machines cater for tube sizes from ¼ in to 2½ in and from 1 in to 4 in respectively.

The MB machines are driven by endless V velts from the motors to the self-contained automatically lubricated headstock. The spindles are mounted on phosphor bronze replaceable bearings. Alternative forms of gearboxes are available; either a multi-speed unit with nine spindles giving a range from 18 to 150 r.p.m. in the 2½ in machine and from 12 to 101 r.p.m. in the 4 in machine, or with pick-off gears to give any one of 12 standard spindle speeds. The range in that case is from 15 to 154 r.p.m. and from 10 to 101 r.p.m., respectively, in the two machines. The handling capacity for bolts is from ½ in to 2½ in and from 1 in to 3 in in the two cases.

All-steel tangential dieheads are used with automatic releases to give a predetermined length of thread. Lever release is also provided and the head can be closed by way of the hand lever or through the rearward movement of the saddle. The latter is of narrow guide construction to provide consistently accurate alignment and is fitted with a robust carriage fully adjustable in both the vertical and horizontal directions. Left and right hand threads provide rapid self-centring and interchangeable nuts are incorporated in the jaws. The hammer blow vice reduces operator fatigue. Provision is made for the removal of large amounts of swarf. The coolant is circulated by an electric pump. The bed is very rigid and the length can be extended in increments of 12 in to suit special requirements. *Landis Machine-Maiden Limited, Hyde, Cheshire.*

BELT CONVEYOR

Easy to Clean



A new conveyor has a quick release mechanism that enables cleaning to be carried out under the belt without stopping the main drive.

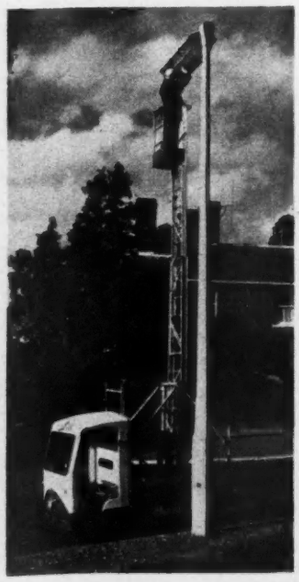
On the return side of the belt is a snubbing roller at the drive end, round which an additional length of belt passes. Releasing the handle moves the roller so that the additional length is freed to permit the carrying strand to be lifted clear, or the return strand to be pulled downwards, giving access to the skid plates.

The conveyor illustrated is fitted with a double-faced white pvc belt running over raised Dural skid plates ¼ in thick. Other types of belt and plate can be supplied. The complete guide rail system is formed of ½ in diameter stainless steel rails with removable and adjustable stops fitted across the running lanes.

The guide rails are supported from robust mild steel bridges straddling the conveyor, cadmium plated and passivated, and having vertical adjustment above the belt. The guide system with the bridges is made to hinge back through 90° in sections and to remain in a vertical position at one side while cleaning takes place. There are no exposed butting rails, the sections being held and covered by sleeves shaped so that there is no hindrance to the passage of the product being carried. It is particularly suitable for filling and packing operations. *Farrow and Jackson Limited, 41-42 Prescot Street, London, E1.*

SERVICE TOWER

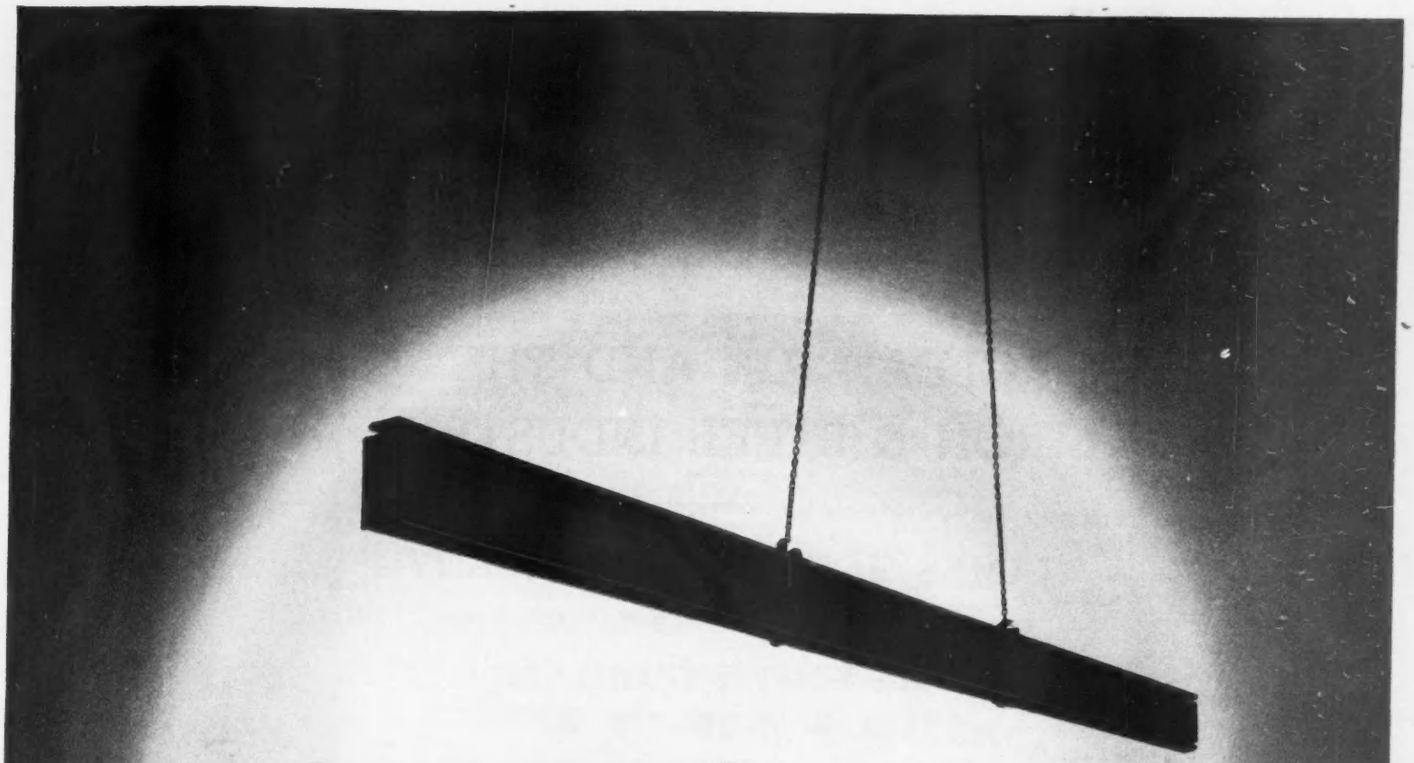
With Carrying Truck



The Tallescope is a service tower standing on an electric truck from which it can be removed if desired.

The complete unit is a Harborough truck with an Access telescopic tower. The tower base is only bolted to the truck and, when removed, leaves the latter free for use as a flat-body vehicle.

The base of the tower is fitted with adjustment for levelling so that the tower can be set vertical in spite of road camber. An angle of 15° can be allowed for. The tower is made of aluminium alloy and has a working height of 26 ft. Mounted on the truck the height is increased to 28 ft. For transport the tower is retracted and swung forward from the pivot on the base so that the platform projects some 4 ft in front of the truck. Quick clamps lock it in the vertical position. The truck measures 10 ft 3 in long. Its height is 7 ft 4 in with the tower lowered, and the width 4 ft 2 in. *Access Equipment Limited, Maylands Avenue, Hemel Hempstead, Hertfordshire.*



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HOWDEN

Human Element

Early Morning Disturbance

MR. DUNCAN SANDYS, the Minister of Aviation, took with stalwart good humour the dawn arrival on his doorstep of sixty demonstrators, men, women and children from the London Airport area, whose own sleep is frequently shattered by the night time operations inseparable from a major international airport.

Mr. Sandys, in blue pyjamas and a dressing gown, discovered that the cause of the residents wrath was his decision to allow night jet flights from London Airport. He told them in what went on as a friendly if extraordinary interview, that he had insisted that night flying jets should make no more noise than piston engined aircraft.

There is a genuine clash of interests here. No one likes suffering a particular ill for the general good. If reasonably full freedom for all aircraft to come into London is not granted then its chance of becoming the centre of airline movements in the northern hemisphere may well be lost, to the Dutch or to Western Germany. Yet the local residents, who are by no means a small number, have the peace of their home life constantly destroyed. The effect on property is not likely to be reassuring to home owners in the area.

Again, there is a difficulty in that if a pilot is to climb rapidly to remove his noisy craft into the upper air with all speed, then the noise on the lower part of the climb will be the more upsetting to those within range. If he is made to keep down the noise by restricting the angle of climb then he remains, less noisily, at lower levels for a longer time.

When a solution is found to getting air passengers into city centres at something more than horse-carriage speed then it may be possible to put the airports outside the suburban areas. But by then London Airport will have cost so many tens of millions that the Government will not sanction tearing it down.

Revolution for Young Workers

While it may not affect the existing practices of the leading firms in education-on-the-job, the intention of the Government to look into making day-release for young workers a right, and not a privilege, could have sweeping repercussions for other—especially smaller—employers.

With evening-class-only study increasingly out of fashion for serious professional and technical qualifications and with the need for more and more skilled men in industry generally acknowledged, it is only a matter of time before this reform comes.

If the standard of engineering and of operatives performance in production is to be equal to that of the engineers and scientists in research and development then a vast increase is plainly called for in the number of properly qualified men.

Yet it remains true that a big gap exists between the practice of the leaders in employee training, both in the works and by release to educational establishments, and those who do not care to follow.

This clue to the Government's thinking was given by Mr. Kenneth Thompson, the Parliamentary secretary to the Ministry of Education, at Newcastle upon Tyne at the beginning of the month. He might find the idea running into strong industrial opposition over his remark that the present release on a voluntary basis could be extended to include non-vocational courses at a craft and technical level.

Opportunity and Encouragement in the CEGB

Throughout its administration and its 238 power stations the Central Electricity Generating Board employs 53,000 people. No less than 2,000 of them are students or craft apprentices engaged on a formidable variety of full time courses.

They might not accept the term but the elite are 75 graduates in mechanical or electrical engineering or diplomatists from the technical colleges. They are divided between two two-year courses, one on generation, the other on transmission. The generation course, on power station maintenance and operation, is divided between basic workshop training, 16 months in power stations, one on transmission work, one on distribution, and six months are spent with an electrical engineering manufacturer.

The transmission course—the operation, maintenance and construction of grid lines—is divided into basic workshop training, 12 months of transmission and technical, three of system operation, two in a power station, one on distribution and, again, six months with a manufacturer.

In the training period the 1st and 2nd class honours man is paid £600 the first year and £640 the second. The 3rd class honours and pass man is £40 behind in each stage. For non-graduates the level is £460 at 20, £515 at 21 and £560 at 22 and over.

Starting off after training at £710 a year as a general assistant engineer, the aspiring engineer has a ladder before him reaching to second assistant engineer at £1,025-£1,450 a year. Above that there are the managerial and higher executive grades beginning at £1,540 a year.

The CEGB also has very nearly 1,000 student apprentices for whom the qualifications are either GCE "A" level passes in mathematics and physics and "O" level passes in English language and two other sugjects, or GCE "O" level in mathematics and physics or possible general science, English language and two other subjects.

The "O" level entry is at 16 or 17 years and for "A" level, 18 or 19 years, this category taking a sandwich course.

The five year student apprenticeship scheme gives the same basic training as to craft apprentices (of whom there are also almost 1,000). The student apprentices then go on to engineering training in a power station for plant operation, the drawing office, control room, laboratory, electrical and mechanical maintenance, meters, instruments and administration.

Prospects of the apprentices after training are, says the CEGB directly, "as for the graduate trainee."

Others among the CEGB's future operators and administrators are fifty apprentice draughtsmen, 150 chemists and a number of civil engineering apprentices.

Education Officer for Works Managers

The growing educational interests of the Institution of Works Managers are reflected in the appointment of an education officer of a very wide teaching experience and acquaintance with industry.

The IWM's first education officer is to be Mr. Lawrence Sutton, who has had a long career with Ashridge College and left there as Director of Studies.

Mr. Sutton joined Ashridge in 1931 as senior tutor with industrial subjects in his brief.

Serving in the war with the Royal Engineers he worked with the Control Commission in Germany from 1945 to 1950. He had the specific task of removing the Nazi taint from the University of Goettingen and reopening it in accord with its former liberal tradition.

Since 1950 Mr. Lawrence's teaching at Ashridge has been mainly concerned with industrial economics and communications. From 1956-58 he was a council member of BACIE and joined in that body's work on industrial education.

As educational officer for the Institution of Works Managers, Mr. Lawrence will collaborate with Technical Colleges in the conduct of the IWM's two-year training course. The course is now available in 12 provincial centres and in London.

More than 100 students qualified last year for the certificate of the Institution.

Well, What do the Workers want ?

When a shop steward convenor for a works of 10,000 men, or a general secretary for a union of several hundred thousand, describes what the operative wants, are we being told what he really does want or what the speaker thinks he ought to want?

Probably a bit of both in most cases.

But the majority of men are content to have a small group speak for them and an assessment of this question has to be made. Mr. J. Cooper, chairman of the multitudinous National Union of General and Municipal Workers, told the Midland Management Conference of the British Institute of Management that this was possibly an unavoidable problem in modern society with its organisation and specialisation of industry.

What did Mr. Cooper think that people wanted?

He did not confine himself to setting out his own views. Going back to his membership of the Duke of Edinburgh's study conference on the Human Problems of Industrial Communities, in 1956, Mr. Cooper recalled that union and management at those meetings found many points on which they were agreed.

Most put wages as priority number one. After that security—freedom, that is, from the risk of sudden dismissal—and then as good an "atmosphere" at work as possible. Tied up with security was the need for personal recognition, the need to feel part of a joint endeavour.

The answer to the question, "What does the worker look for?" carried a number of implications for management. In Mr. Cooper's view, these were the need for sound leadership, the vital importance of good communications and the selection of foremen, coupled with good selection of men for appropriate jobs. Among suitable training facilities the union's chairman included the inculcation of the need for team work.

His three points on public relations were all closely related. They were that the firm's business should be explained sufficiently to make the work a challenge, that the company should make it plain that it operates on the basis of fair play and that it should consider changes in public opinion in relation to industry.

Reorganisation Plan for a Polytechnic

Radical changes approved in principle for the Regent Street Polytechnic would lead to the establishment of three colleges: one of engineering and science, one of architecture and advanced building technologies, and one of commerce, probably with management studies included.

The proposals have been approved in principle by the further education committee of London County Council who envisage a federal form of organisation linking the three colleges.

Two of the colleges would occupy the existing Regent Street site, and the architecture and building college would move into part of a site in use in the Marylebone Road.

The governors of the Polytechnic have accepted the proposals. While seeking to remain in the forefront of technological institutions the Regent Street "Poly" is consciously trying to avoid becoming typed in the technologies to which its studies are directed. The federal style of the plans, in which each college would have as much independence as possible, resembles some developments abroad.

From its present 2,000 full time students, divided into a dozen faculties, the scheme may see an increase to around 2,500. It may well bring about a welcome strengthening of the standard of engineering and other work undertaken at the Polytechnic.

While the timing is still not certain there is some expectation that the changes will be well advanced by the mid-1960's.

Rise in Shipyard Unemployed

A seven per cent rise, 901 men, in the number of unemployed in shipbuilding and marine engineering is shown by the final Ministry of Labour return for March.

The only other increase shown by the Ministry figures is one of 1,075 in textiles. In construction there was a fall of 11,000 in the numbers of unemployed and the other major improvements were 4,300 more in work in agriculture, forestry and fishing and 2,200 in engineering and electrical goods.

The overall total of unemployed on 14 March was 413,000, of whom 62,000 were married women. Of those without work, 232,000 had been out of employment for more than eight weeks.

Engineering Growth in Northern Ireland

Since the war 140 new firms have set up in Ulster. In an area where labour relations have a tranquillity unknown on the mainland, the advantages to the industrialist seeking expansion are many and enticing.

By H. J. Novy

THE popular picture of Northern Ireland, Lord Chandos told me recently, is "one of a great linen and shipbuilding area which produces more field marshals to the square yard than any other." He went on to depict a lively and dynamic industry, much of it grown up since the war, whose growth rate is equal or greater than that exhibited by other industrial centres in the United Kingdom.

It is not "industrial looking" as most of us imagine it might look to fit with the scope of its activities. Much more does the picture remain of green fields, singing streams, hospitable country inns where excellent food is served, fishing for trout or salmon and yachting at Newtownards or Coleraine.

The dominant impression is of a pleasurable land, not a beehive of industry. But, said Lord Chandos, "people who are going in there are not going into a green field, they are going into an already industrialised area." In various statements made in his capacity as chairman of the Northern Ireland Development Council, he has advocated the choice of Northern Ireland as a location for a new factory. The Irish Sea is not a barrier for firms making the right type of goods, as some 140 new firms have proved since the war.

I went to look for myself, after a careful study of the contents of a folder bulging with statistics and accounts of the area's industry. I had landed among the hares at Nutts Corner, outside Belfast, many times before and visited firms old and new, from the very large to the very small. This time I went there looking for clues—how and why had Ulster's industry developed into the present varied structure, what were the basic factors affecting her industrial re-birth, what was her future likely to be?

Having accepted the political importance to the United Kingdom Government of reducing unemployment, and not wishing to discount the considerable and sustained efforts of the NIDC in promoting the area's claims as an ideal home for new enterprise, I still felt that something more than subsidies and propaganda underlay the area's industrial growth.

What I discovered confirmed this feeling.

COTTON THE PIONEER

Manufacturing industry began in the eighteenth century with the processing of home grown flax, as an extension of the area's agricultural activities. Until the early part of the nineteenth century there was no substantial industrial growth. It began in earnest with the establishment of the cotton industry and the introduction of steam engines and cotton mills. The first was installed in 1790 and by 1814 there were 15 in use in Belfast.

Cotton was the great pioneer of mechanisation and factory organisation in Belfast as it was in Glasgow and in Lancashire. In the 50 years of cotton's ascendance the population of Belfast rose from 13,000 to 37,000 and the need to maintain the mills' machinery laid the foundations of an engineering industry. When the area's cotton industry was overwhelmed by the superior strength of Lancashire the spinners successfully turned to flax and so laid the foundation of Northern Ireland's largest single industry.

The rapid growth of linen textiles provided the necessary basis for the establishment of a strong textile machinery industry, in which James Mackie and Sons Limited and Fairburn, Lawson, Combe, Barbour Limited were the leading firms. The latter withdrew from Northern Ireland in 1955. James Mackie remains one of the leading firms in the UK in the specialised manufacture of a complete range of machinery for the processing of flax, jute, hemp and other hand fibres.

The tremendous upsurge of manufacturing industry in the Belfast area after 1850 more than matched growth in the United Kingdom's other main industrial centres during the same period. No area acquired so diverse a range of industry: shipbuilding and engineering prospered, defying all laws relating to the essential proximity of raw materials but it may be significant that those sections which developed most exported a large proportion of their output to world markets, such as tea and coffee estate machinery, ventilation and dust collection plant.

CHALLENGE OF UNEMPLOYMENT

Northern Ireland has a population of 1·41 million, of whom 476,000 are insured workers.

By 1966 it is expected that the population will have increased by a further 50,000 despite emigration which has gone on at varying rates throughout the history of Ulster. Some 86,000 have emigrated between 1951 and 1959, an annual rate of 9,500 which is expected to increase rather than decline over the next decade.

The birth rate is the highest in the United Kingdom and the death rate the lowest. Unless the expansion of industrial activity matches this relentless expansion in the area's human reserves the only relief to mounting unemployment will be a higher rate of emigration. Since the people in the area have proved themselves throughout their history to be highly adaptable and trainable in a wide range of skills, industrious and co-operative—as has been reported so consistently by those manufacturers who have selected Northern Ireland as a site since the war—it could be most unfortunate if an alternative is not found.

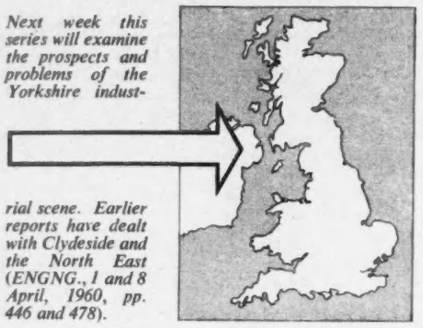
As Lord Chandos never tires of pointing out, the problem is not a very large one. Unemployment averaged 36,900 in 1959 and has been as high as 47,000 (1952) in the last decade. The scale of the problem, therefore, is to find new industry to absorb this persistent surplus of labour—between 35,000 and 45,000 jobs, 70 per cent of them for men. This amounts to about the same as the number of jobs which have been created since the end of the war by the arrival of new industry or the expansion of existing business.

PATTERN OF EMPLOYMENT

Employment among the industries is shown in the table. It indicates the proportional changes in the number of insured workers in each industry. Notwithstanding the usual difficulties that arise when broad trade groups are being considered—important variations within them—a broad pattern emerges fairly clearly.

The linen industry is still the largest single trade group (if shipbuilding and engineering are separated, as I endeavour to do later on) but is contracting slowly and has done so at the average rate of just over 1 per cent a year over the past two decades. But the rate of decline is increasing: between 1956 and 1957 it was 4·9 per cent and the following year 14 per cent. Its manpower has fallen by nearly 20,000 in two decades.

Next week this series will examine the prospects and problems of the Yorkshire industrial scene. Earlier reports have dealt with Clydeside and the North East (ENGNG., 1 and 8 April, 1960, pp. 446 and 478).



As in Lancashire's cotton the contraction is greatest at the coarse end of the trade. Some expansion still goes on at the very fine end. The situation could doubtless be improved by rationalising the industry and increasing the scale on which it carries out research. The vital research now going on—in a country house—on the blending of man-made fibres with linen is as yet on a very small scale. Industries, like individual firms, tend to be timid in so far as their traditional products are concerned. The Irish linen industry is no exception.

MAJOR CHANGE IN TEXTILES

The contraction in the linen industry is being offset to some considerable extent by the expansion of other textile industries, particularly man-made fibres, and the clothing industry.

A most significant development in this direction was the setting up of a rayon plant in Carrickfergus near Belfast by Courtaulds in 1950. They employ over 1,200 people in what is one of the most modern rayon plants in the world, with an output of 17 million lb a year. They are also making the sulphuric acid and the carbon disulphide used in the process.

In a recent statement, Sir John Hanbury-Williams, chairman of Courtaulds, dwelt on the advantages of the location, based on the experience of nearly 10 years: "We were right in assuming that labour, both men and women, was keen and plentiful and that we would have no difficulty in maintaining a three-shift system non-stop throughout the year. Thanks to Northern Ireland's sound manufacturing tradition, absenteeism and labour turnover are negligible, and we find that after training to our specialised requirements, labour is just as good as in any other of our factories in the United Kingdom. . . . varied and remarkably efficient freight services have provided a reliable service which enables us to move more than 110,000 tons of raw materials and finished products to and from our plant during each year." Sir John's remarks are profoundly significant: they may provide the clue to Northern Ireland's search for a new basic industry, eventually spreading into chemicals and oil.

Since Courtaulds went to Carrickfergus, Chemstrand Limited, a subsidiary of the Chemstrand Corporation, Decatur, Alabama, opened a £3½ million plant for the manufacture of acrylic fibre and Imperial Chemical Industries have purchased a two-hundred acre site at Kilroot, County Antrim, and expressed their intention to build a major Terylene spinning plant. They are likely to spend at least £10 million on the project, which it is expected will employ 2,000 people by 1963/64.

These enterprises by large international companies could completely transform the situation, not so much by their direct employment of labour but by the attraction of man-made fibre using industries, who are major employers of the kind of labour currently being released by the linen industry.

One of these, Berkshire Knitting (Ulster) Limited, another American subsidiary, actually started to manufacture women's hosiery before

Courtauld's new plant was in production.

This company has now built two factories and expanded their labour force from 320 in 1951 to some 800 in 1959 and will shortly recruit another 150. Their story is one of gradual expansion built upon successful operations, largely with local labour and management.

Their chairman, Mr. Ferdinand K. Thun, explained that the success of this operation was due in the main to suitable labour and to the friendly assistance of the Government of Northern Ireland, "who have at all times gone out of their way to help us solve our problems."

Between the end of last year and the beginning of 1945 some 32 textile and 29 clothing manufacturers have established themselves in Northern Ireland. There would seem therefore to exist a good nucleus of the newer textile industries and, if the expansion of Courtaulds and Berkshire Knitting is anything to go by, conditions are as propitious as it is possible to make them. I would expect therefore to see the man-made fibre industry of Northern Ireland expand considerably over the next decade and to become as basic to the area's economy as linen ever was and to provide the linen industry itself with a good opportunity to blend its products into newer fabrics.

CHEMICALS MAY GROW

The chemical industry does not figure in the table or any other statistics of the area. Yet there have been signs recently that it may grow substantial roots during this decade. As the enterprise of ICI at Billingham has demonstrated, chemical manufacture is a highly integrated business with numerous closely interconnected branches, which spread and cover thousands of acres.

The decision of Du Pont Nemours to set up a major production unit for Neoprene synthetic rubber is therefore of the greatest importance. Oil is the principal raw material and it can be imported into Northern Ireland as easily and cheaply as it can into Wales or Lancashire. The fantastic size of demand for Terylene and similar fibres could take Northern Ireland one step further along the path to chemical manufacture.

Already plastics, dyestuffs and pharmaceuticals have made their appearance and there is every prospect of further rapid progress. In this field more than most the remark that Mr. Michael Halls—a senior Board of Trade official concerned with the administration of the new Local Employment Act—made at the Midlands conference of the British Institute of Management applies with great force in Northern Ireland's favour. "Proximity to raw materials," said Mr. Halls, "is not necessarily any longer a basic locating factor."

ENGINEERING'S PATH

The growth of the engineering industry in Northern Ireland was based on the country's original basic industries: cotton, and later flax, laid a foundation upon which grew a very live textile machinery industry which later specialised in the processing of hard fibres. The shrinking of world markets for such machines—exports were traditionally high, 50 per cent or more of output—led to a decline in this section of engineering. Some firms closed their factories, others introduced new products.

The engineering industries of Northern Ireland have expanded substantially since the war—from 19,000 in 1934 to 44,000 in 1950 and 52,000 in 1959. They account for a major proportion of Ulster's new immigrant industries and they include large and most important companies, such as Associated Electrical Industries, Birmingham Sound Reproducers, International Computers and Tabulators, Lines Brothers, Pye, Wellman Smith Owen Engineering and others.

There is no clearly recognisable pattern, unless such diverse activities as manufacture of electrical turbines, computers, punch card machinery, electronic controls and record players can be grouped under the general heading of electrical engineering.

In most cases the main reason for established and large concerns going to Northern Ireland was the availability of abundant labour with a tradition of skill and adaptability.

Short Brothers and Harland set up in Belfast in 1937 to manufacture aircraft. The location was strategically sound, facilities for the building and testing of seaplanes (then believed to be the answer to the submarine menace) quite unique. Short Brothers and Harland became one of the major employers of labour in the area, with a force exceeding 20,000, and continue to be relatively large.

Their production is being diversified, and already includes electronic control instruments, analogue computers, domestic vacuum cleaners, mechanical handling machinery.

The value of Northern Ireland's engineering activities in 1958, including the output of the largest shipyard in Europe—Harland and Wolff, the best known engineering firm in Ulster—reached a figure of almost £79 million. The number employed in the engineering industries was approaching 53,000.

The largest of all the engineering factories erected since the war is Associated Electrical Industries' turbine plant at Larne which was completed in 1957 and covers an area of 600,000 sq. ft. It was built by the Ministry of Commerce under a repayment plan and the final cost of the factory and its equipment is expected to exceed £12 million.

AEI's chairman, Lord Chandos, had much praise for the high quality and adaptability of local labour. The cooperation of the Northern Ireland Government has been in this case, as in all the others, absolutely first class. A new technical school was erected to provide the skilled personnel required and communications have been greatly improved by the building of new roads which include a direct link from the AEI factory to the Belfast trunk road to enable heavy loads to move to an fro from the Belfast docks.

The second major firm in Larne is Corran Works Limited, a subsidiary of Pye which has been in occupation of a Government factory since 1947 where radio and television equipment is made. Comments from other large engineering firms operating in Northern Ireland are generally favourable.

Mr. A. J. Moore, director of UK Optical Bausch and Lomb Limited who manufacture at Lurgan, County Armagh, said that when they moved in 1946 "a vacant factory was the original inducement," planning permission to build in London having been refused. Since then the factory area has been more than doubled (120,000 sq. ft) and the branch factory has far outstripped the parent at Mill Hill.

There is room for further expansion on their 8 acre site and the company are well pleased with the workers they have recruited. Mr. Moore commented that "the manual dexterity of the linen workers has readily been adapted to the precise operation of the optical industry" and individual relations between men and management have been very good.

NOT ISOLATED

On the subject of the Irish Sea and the distance from base Mr. Moore said that the twin problems of distance and isolation had proved negligible: "Company executives have generally found it pleasant to move from London to the calmer tempo of Lurgan, a typical Ulster provincial town set amid busy farmland."

Most of the immigrant industrialists found the labour adaptable and easily trained, absenteeism very low and labour turnover negligible. In the case of UK Optical it has been as low as two employees (out of 350) in a year. Sir Cecil Weir, chairman of Industrial Computers and Tabulators who employ over 2,200 people in a plant covering 500,000 sq. ft at Castlereagh near Belfast (twice extended since the original move), was strongly impressed by operating conditions and labour: the site was large and allowed a flexible layout, the quality of the factory buildings was excellent, and the quality of skilled operators (after what he admitted had been a major training exercise) as good or better than anywhere in the UK.

"We were attracted to Northern Ireland," he said recently, "by, among other things, the availability of labour and the tradition of engineering skill and craftsmanship for which the province is noted." The company's expectations have been realised in full and the plant is now the largest in the ICT group.

I was curious to find out how the Ulster location suited smaller firms, and visited two of these. One in Ballymena, Flexibox Limited, who are a branch factory of the Manchester manufacturer of precision mechanical seals and the other in Ballymoney, K.G. Corfield Limited, who are said to be the only makers of high precision cameras in the UK.

Flexibox moved into an existing factory because this was the quickest way of expanding at low cost. The work is to exceptionally close tolerances, nearly all in stainless steel, and the results have been most gratifying.

TOO MANY CARROTS

The potential of Ulster as a location for industry requiring a higher than average amount of management and skill is good.

I left Ulster with the feeling that it could well be that the Northern Ireland Government are paying out rather more than they need to attract industry. They have invested £20 million in factories and paid out £22 million in grants of various kinds. Factories covering four and a half million sq. ft have been built by the Government and one and a half million sq. ft is now building or on the drawing board.

I think that the Government might be better advised and use their money more profitably on deciding—and it can be decided—on the basis of ascertainable facts projected into the future—what type of industry should exist in the region. They could then take steps to establish the facilities—a la Wilton, perhaps—needed by such an industry. Man-made textiles and other petroleum chemicals spring to mind, especially in view of the most recent developments in these branches of chemical engineering.

Northern Ireland: Employment in Trade Groups, 1935 to 1957

Trade group	Number employed (000)			Percentage change in employment	
	1935	1949	1957	1935-1957 Per cent	1949-1957 Per cent
Linen industry	57	53	43	− 23·4	− 17·3
Other textiles	10	12	16	+ 56·5	+ 36·9
Total textiles	67	64	60	− 11·1	− 7·3
Clothing	14	21	24	+ 73·9	+ 16·6
Engineering and metals	19	46	52	+175·1	+ 12·5
Food, drink and tobacco	11	19	25	+122·2	+ 30·9
Mineral products	2	3	4	+144·4	+ 26·5
Timber and furniture	2	4	3	+ 69·7	− 26·4
Paper, printing, etc.	5	5	5	+ 11·6	+ 7·6
Misc. manufacturing trades	1	4	4	+228·0	+ 1·0
Total manufacturing trades	120	166	177	+ 46·9	+ 6·4
Building and civil Engineering	14	25	26	+ 83·2	+ 5·0
Gas, electricity and water	4	6	7	+ 61·7	+ 8·1
Totals	139	197	210	+ 51·1	+ 6·3

These figures have been taken from *Reports on the Census of Production for Northern Ireland* and relate only to firms employing ten or more people.

Fatigue Criteria in Welded Structures

The fatigue capacity of welded structures is limited by stress concentrations due to geometry and weld defects as well as metallurgical changes due to welding. Remedies include machining the welds, induction of local residual stresses and careful design.

THERE seems to be a tendency among both research workers and practising engineers to over-simplify the question of structural design criteria. Thus, the criteria of static load-carrying capacity and limiting static stress, which receive much attention, are concerned with only one important aspect of behaviour. Against this background the arrangement of a symposium on another aspect of structural behaviour, that of fatigue, by the British Welding Research Association and the Engineering Department of the University of Cambridge, was timely indeed. The meeting was held at Cambridge between 29 March and 1 April. In his foreword to the published papers,* Dr. R. Weck remarks that the fatigue behaviour of welded structures has never before been the single subject of a conference and that the last decade has produced increasing evidence of the importance of fatigue strength as a criterion of structural strength.

Eleven papers concerned with the fatigue behaviour of welded structural assemblies, elements and joints, fabricated from steels and aluminium alloys, were presented at the symposium by authors from abroad as well as the United Kingdom. Mild steel construction featured prominently, five of the papers being concerned mainly with this topic. Two other papers were concerned with high-tensile steel construction, two with aluminium construction while two more were devoted to proposals for future research.

STRESS CHANGE BY INDUCTION

In his paper "Fatigue Strength of Fillet Welded Joints in Steel," Mr. T. R. Gurney (BWRA) reviews briefly the present state of knowledge of the fatigue strength of fillet welded joints in mild steel. A comparison with some typical experimental results, for 2×10^6 cycles of loading, of the relevant clauses of some current design specifications including BS 153 (1958) "Steel Girder Bridges" follows. It is suggested that in some circumstances the stress allowed in the weld by this specification may be a little optimistic. After considering the factors affecting fatigue strength, such as the stress concentrations at the extremities of welds, it is noted that all fillet welded joints have relatively poor fatigue strengths and that tests on similar joints in high-tensile steel have given results substantially similar to those with mild steel. Finally the influence of residual stresses is considered. It is stated that their induction is at present the only obvious method of producing significant increases in fatigue strength and current work in this field using local or "spot heating" is reviewed.

The paper by Mr. R. P. Newman (BWRA) "Fatigue Strength of Butt Welds in Mild Steel" begins with a discussion of methods used for determining the fatigue properties of welded joints, followed by a comparison in some detail of reported fatigue strengths of axially loaded butt welded joints. After considering the influence of weld defects it is noted that fatigue strength can vary widely, depending upon the form of joint. Among the data quoted are fatigue strengths of 16 tons per sq. in for black mild steel plate and 11·5 tons per sq. in for similar plate with a transverse butt welded joint with the weld reinforcement left on (both loads being pulsating tension for 2×10^6 cycles), i.e., a reduction in strength due to the joint of some 28 per cent. The strength is shown to be improved substantially by machining the welds to remove the reinforcement and thus the stress concentration effect caused by the change of section at the edge of an unmachined weld. Evidence of the value of the induction of residual stress by spot heating is given. Finally, current design rules, such as are contained in BS 153 (1958), are discussed in relation to experimental data. It is noted that good quality welding is essential if a positive factor of safety on experimental values is to be provided by the rules. (The results quoted in this paper indicate marked superiority of butt welded over fillet welded joints.)

IMPROVING BUTT WELDS

Although not concerned specifically with mild steel construction, Dr. Werner Gilde (Central Institute of Welding, West Germany) in his paper "Increasing the Fatigue Strength of Butt Welded Joints" is complementary to that by Mr. Newman. After stating that the fatigue strength of structures subjected to dynamic loading is reduced considerably by welded joints and that in this respect high tensile steels have little advantage over mild steels. Dr. Gilde proceeds to consider the reasons for this state of affairs and its remedy. He suggests that the fatigue limit of butt welded joints depends upon the roughness of the surface of the weld bead and also upon the surrounding medium. Experimental results for specimens in bending are given which are interpreted as indicating that by covering the weld bead with plastic materials, e.g., epoxy resin, the fatigue strength of butt welded specimens can be improved by 75 per cent. This improvement is stated to be due to the smoother finish afforded by the plastic and its effect as a surrounding medium.

The paper "A Systematisation of Fatigue Strength Values of Mild Steel Welds," by Mr. A. Neumann (Central Institute of Welding, West Germany) is concerned with the examination of results of fatigue tests of all kinds of welded joints in mild steel to determine parameters of minimum fatigue strength so as to extend Stussi's "general theory for fatigue strength of materials and notched bars." The work is not yet complete but on the findings made so far the author proposes that permissible stresses for welded structures be based upon factors of safety of 1·5 to yield point for static loading and 1·2 to endurance limit for dynamic loading.

Dr. W. H. Munse and Dr. J. E. Stallmeyer (University of Illinois, USA) consider the effect on girder fatigue strength of such welded details as stiffeners, splices and cover plates in their paper "Influence of Weld Details on Fatigue of Welded Beams and Girders." The results of tests on beams with such details are compared with those of tests on plain plate, rolled I beams and welded I beams. It is concluded that welded details all reduce the fatigue resistance of beams, but that structures with adequate fatigue capacity can be obtained by careful design based on an understanding of the working conditions. An interesting comparison is provided in their Table VI which is reproduced in the previous column.

Summary of Approximate Fatigue Strengths of Welded Beams with Various Details
(Zero-to-tension cycle)

Member or Section	Fatigue Strength, lb per sq. in 2×10^6 cycles	Ratio to Plain Plate
Plain plate	31,700	1·0
Rolled I beam	31,200	0·98
Welded I beam	26,000	0·82
Welded beam with stiffeners	23,000	0·73
Welded beam with splice	20,000	0·63
Welded beam with butt-welded flange transitions	19,000	0·60
Welded beam with partial-length cover plate	12,500	0·39

In their second paper, "Fatigue of Welded Joints in High-Strength Steels," Dr. Stallmeyer and Dr. Munse discuss the fatigue strengths of various types of welded joint in alloy structural steels with ultimate tensile strengths ranging from 33½ to 67 tons per sq. in.

The types of joint considered include transverse and longitudinal butt welded joints, longitudinal fillet and T-fillet welded joints. From the results of numerous tests, it is concluded that in order to obtain maximum improvement over ordinary structural steel it is necessary to control weld defects to a much greater degree for the high strength steels. It is noted that while average test results indicate relatively little advantage by using high strength steels where a large number of repetitions of stress is expected, maximum values of fatigue strengths of butt welded joints incidate the possiblity of strengths much greater than those obtainable with ordinary structural steel.

The paper "Programmed Fatigue Testing of Full Size Welded Steel Structural Assemblies," by Dr. J. G. Whitman and Dr. J. F. Alder (Military Engineering Experimental Establishment, Christchurch) is of the nature of an interim report on the fatigue testing of military bridge assemblies of welded high tensile steel. A fatigue testing machine specially developed for testing bridge panels is described and the results of tests using a pulsating load of constant amplitude and programmed mixtures of load amplitudes are given. Complete severance of the tension chord was used as the criterion of failure. The results of the tests indicate that the spread of a fatigue crack in assemblies of the kind considered is slow and that by applying initial overloads of approximately two-thirds of the yield strength a slight but significant increase in the fatigue life of assemblies is obtained.

LIGHT ALLOY STRUCTURES

Turning to the papers on the fatigue in aluminium construction, the paper by Mr. J. E. Tomlinson and Mr. J. L. Wood (British Aluminium Company) "Factors Influencing the Fatigue Behaviour of Welded Aluminium," first outlines the general fatigue behaviour of aluminium alloys used in welded construction. Published work is then reviewed to call attention to the factors which influence the behaviour of welded connections. From the results of tests it is concluded that there is sufficient evidence to show that the fatigue strength of sound as-welded simple butt joints rises significantly with rise in static strength. It follows that improvement by ensuring freedom from defects and dressing the weld flush with the parent metal is possible.

It is suggested that for successful designs of high efficiency, methods of improving fatigue strength by mechanical or thermal treatments might have to be adopted. Further information is needed, however, before safe stress levels can be established.

In their paper "Effect of Mean Stress on Fatigue Properties of Aluminium Alloy Butt Welded Joints," Mr. K. W. Gunn and Mr. R. McLester (Aluminium Laboratories Limited) report the results of axial load fatigue tests on butt welded joints in sheet and plate conforming to BS 1470 for NS 4½H, BS 1477 for NP 5/6M, and BS 1477 for HP 30 WP, using mean stresses of zero, 1½, 3, 5 and 7 tons per sq. in. It is concluded that the three alloys have similar fatigue strengths when butt welded and that, with increasing mean stress up to 4 tons per sq. in, the range of stress for a particular endur-

Continued foot of next page

* The papers have appeared in the March and April issues of *British Welding Journal* (vol. 7, Nos 3 and 4, 1960).

Freezing and Thawing of Lightweight Concretes

Intentionally entrained air is essential to concretes made with lightweight aggregates if they are to possess durability under conditions of freezing and subsequent thawing. Experiments that checked this suggestion were in a paper entitled "Freezing and Thawing Tests of Lightweight Aggregate Concrete," presented to the American Concrete Institute's recent annual convention. The authors are Mr. Paul Kleiger and Mr. J. A. Hanson, both of the Research and Development Laboratories of the Portland Cement Association at Skokie, Illinois, USA.

Nine lightweight aggregates and one natural sand and gravel aggregate were used for concretes subjected to laboratory freezing and thawing tests and, in some cases, to tests for resistance to de-icing scaling. The concretes were made at two levels of compressive strength: 3,000 and 4,500 lb per sq. in at 28 days. Both non air-entrained and air-entrained concretes were prepared, using the aggregates in the air-dried and in the 24 hour saturated condition. The results point to the need to evaluate a lightweight aggregate by laboratory freezing and thawing tests of air-entrained samples, as is generally done for conventional concretes.

Spectrograph for Timber Research

A new X-ray apparatus for analysing and testing timber preservatives and flame retardants has been installed at the Castleford, Yorks, laboratories of Hickson's Timber Impregnation Company (GB) Limited.

The equipment is a Philips all-vacuum X-ray fluorescence spectrograph. It is the first of its kind to be installed in Great Britain and the first to be used exclusively for timber research. It is being currently used to analyse Tanolith and Pyrolith solutions from plants gathered all over the world, to check samples from taken impregnated timber already in use, and to resolve points raised during new work.

The sample is bombarded with and energised by an intense beam of X-rays and as a result gives off secondary X-rays of a different wavelength. The spectrometer separates these rays and measures the intensity of each by means of a scintillating counter; the counts are passed to a recording unit. The apparatus accurately completes in under ten minutes analyses that formerly took a day and a half by conventional destructive chemical techniques.

Inflatable Rubber Forms for Concrete Pipes

Construction equipment that builds "instant concrete pipes" in a freshly cut trench at the rate of 8 to 12 ft per minute has been developed by the Fullerform Continuous Pipe Corporation of Phoenix, Arizona, USA. Originally used for putting down conduits for irrigation water on farms, the technique is being adapted to build storm sewers and other types of concrete pipe.

Inflatable rubber and fabric forms, designed by the Goodyear Corporation, from blimp-type materials, are part of the continuous operation process. The method cuts out seams and joints, and reduces construction time and costs. Using two 300 ft inflated forms with only 3 lb per sq. in of air pressure, Fullerform reckon on pouring 600 ft of pipe without interruption. Ready-mixed concrete trucks are used to service the pouring equipment.

The laying machine consists of a double-hoppered machine that is pulled along the bottom of the trench while enveloping the inflated form. The inflated inner is picked up by the outer form and tamping devices tuck concrete underneath it; half of the double hopper places concrete into the bottom of the trench while the other half forms the top of the pipe.

Concrete train laying "instant concrete pipes" using inflated rubber shutterwork.

New In Situ Formwork for Concrete Shells

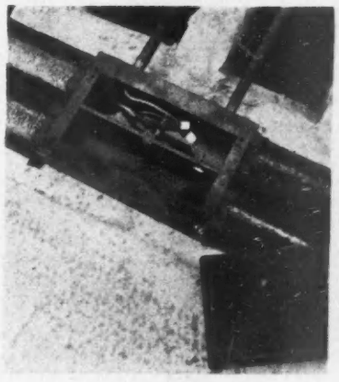
Wire-supported Styrofoam, with its high strength to weight ratio, has been successfully used as a temporary *in situ* shutter for thin concrete shell roofs, giving adequate support while the concrete cures. The Styrofoam also serves as an insulation and vapour barrier throughout the life of the structure.

The method was devised by Professor Joseph L. Waling, professor of structural engineering at Purdue University, and Mr. Longin B. Greszczuk, of the Douglas Aircraft Company, Culver City, California. A description of the method and the way in which it was developed, first on a table-sized construction model and then as a laboratory pilot scheme, was given in the inventors' paper "Experiments with Thin-Shell Structural Models," presented recently to the American Concrete Institute.

Originally the method was devised for simple hyperbolic paraboloids, but shells composed of skewed hyperbolic paraboloidal elements to form spherical and barrel type shapes were also discussed in the paper.

Precast Concrete Units for Module Buildings

During the last few years there has been rapid progress in the use of precast concrete for structural purposes, both for long-span industrial buildings and for multistorey structures. These techniques are primarily a European development, with the lead coming from Scandinavia, the Russias and Great Britain. Buildings of up to 20 storeys have been completed.



Standard junction box for the Key-Bison ducting system.

In 1959, Concrete Limited, whose headquarters are at Hounslow, Middlesex, provided the precast frames for 142 structures for schools, office blocks, factories, and flats. These included blocks of flats of eight and twelve storeys, and buildings of 21 storeys are being planned.

For many years the company have been makers of hollow precast prestressed floor slabs, sold under the trade name of Bison. Now the cavities in these floor slabs have been adapted as a ducting system—to be known as the Key-Bison ducting system—for all the electrical services of a building. For this purpose a standard junction box, with pitch fibre ducts, made by the Key Engineering Company, has been adapted to fit into Bison slabs. Individual floor socket positions can be tapped by drilling through the slab surface to the cavity containing the services. The junction boxes are finished flush with the floor and are suited for taking off power, lighting, heating and telephones. The system lends itself particularly well to the module planning of offices and workshops.

Engineering Achievement of the Year

The St. Lawrence project, involving the power and seaway developments on the United States and Canadian sides of the river, has been named as the outstanding civil engineering work of the year by the American Society of Civil Engineers.

It is the first award of its type to be made by the Society, but henceforth an award will be made annually for the outstanding civil engineering achievement in the United States. Nominations, which are put forward by the directors of the Society in respect of their own districts, are judged on three issues: whether the project demonstrates an improved skill in civil engineering; whether the project contributes to engineering progress; and the project's value to mankind. The St. Lawrence project, which was one of twelve entries considered for the 1960 award, scored high on all three issues.

Continuing **Fatigue in Structures**

ance decreases. For mean stresses above 4 tons per sq. in the stress range is almost constant.

DESIGN TO COUNTER FATIGUE

Finally there are the two papers concerned with future research. Mr. E. M. Lewis (W. S. Atkins and Partners) in his paper "Future Research—Engineering Aspects," suggests two broad fields for future research. One is concerned with economic maintenance and the other with design. The need for appropriate systematic inspection procedures and techniques for detecting fatigue cracking is discussed, together with the question of the evaluation of such cracking after detection. It is proposed that advantage be taken of the beneficial effects of spot heating on fatigue life to enable economical repairs of fatigue cracking to be carried out.

Concerning design, it is suggested that more research into the advantageous use of induced residual stresses is necessary as well as the use of structural forms conducive to the employment of the most fatigue resistant of available welding techniques. Mr. Lewis ends his paper with a plea for centralised environmental testing facilities for welded constructions.

Mr. W. D. Bigg (University of Cambridge) contributed a paper entitled "Metallurgical Aspects of Future Research on Fatigue of Welded Structures" discussing the mechanism of work hardening and its relation to fatigue behaviour together with the need for experimental data on the effects of grain size and dispersions. The special features of a welded joint in which a notch is effectively present and located in the heat affected zone is considered and it is concluded that an evaluation of the metal structures of this zone of welds is desirable instead of the present empirical approach of the mechanical testing of joints.

Improving the Sound of a Car by Panel Treatment

Various aspects of vehicle noise—including tyre noise, panel noise, and the noise produced when vehicles travel over rough surfaces—are studied at the Motor Industry Research Association, Lindley, Warwickshire. For some of the tests an anechoic room is used; this is equipped with a roller with a granite chip surface that can be used to drive any road wheel of a stationary vehicle, permitting measurements to be made under various conditions. Tape recording is used extensively for analysing sounds inside cars.

A recent MIRA report, "The Effect of Panel Damping Treatments on Motor Vehicle Noise," by C. H. G. Mills, J. C. Dixon, and D. Lavender, describes investigations carried out on noise caused by impulsive excitation such as door slamming or raindrops on the roof. The aim behind the tests was to discover how such impulsive noises could be dampened to make a car more acceptable acoustically. Many people tend to rate a car on a scale that ranges from "tinny" to "solid."

As a start, an experiment was made to discover the responses of a group of 20 people to the sounds of slamming of different car doors. It appears that the object was to obtain the response of people inside the car, not outside. Three makes of car were tried: one was consistently rated as the most annoying. Opinion was not so clear as to which was the least annoying. Those people prepared to indicate the properties of the noise by which they rated it annoying used the terms "duration," "pitch," and "tinniness." Only two observers used the term "loudness."

Oscillograms of the sound pressure in the cars due to the slam did not show adequate information to correlate with the antipathy to the one particular car. However, it appears that the most critical aspects of a single impulsive noise heard inside a car are the magnitude of the initial high frequency components and the duration of the noise. A noisy door catch is also disliked.

To assess the performance of damping materials attached to the car panels, two sets of investigations were carried out. In the first the frequency spectrum of a door slam was analysed; in the second a similar frequency analysis was carried out on the sound generated by a $\frac{1}{4}$ in steel ball falling on to the roof from a height of 18 in. In each set of investigations measurements were made with an unlined car, and then with a car lined with various damping materials. The most effective material was a mineral-filled pva emulsion.

Grand Prix Racing Enters a Blind Alley

Almost since its inception, grand prix motor racing has relied to a very great extent upon technical and financial support from the car, accessory, component and tyre manufacturers and also the petrol and oil companies. There is now a danger that this support will be withdrawn.

British motor racing interests have decided that they will not support as the World's Drivers Championship formula the proposals of the Federation International de l'Automobile for the new formula 1961, for cars with an engine capacity of 1,500 c.c. and minimum weight of 500 kg (the FIA is the international governing body on motor racing).

They will, however, support a 2,500 c.c. formula in accordance with the present Formula I regulations (with the exception that a requirement to use commercially available petrol is willingly accepted) as the World's Drivers' Championship for 1961.

They consider that the new Fomula 1 regulations for 1961 should be rescinded, and that the present Formula 1 and Formula 2 regulations, suitably amended in regard to fuel, should continue to apply for a further period of three years commencing 1961, as the only step that can now have a majority support from industry internationally.

These decisions were unanimously agreed at a meeting which took place in London recently which included the following companies and organisations: Aston Martin-Lagonda, Jaguar Cars, Lotus Engineering, Cooper Cars, Owen Racing Organisation (BRM), Vandervell Products (Vanwall), British Petroleum, Shell International Petroleum, Esso Petroleum, C. C. Wakefield, Laystall Engineering, the British Racing Drivers' Club and the chairman of the Society of Motor Manufacturers and Traders sporting subcommittee.

These organisations who have, until now justified support for motor racing as a means to technical development and publicity, consider the new regulations, if introduced, would restrict technical development and reduce public interest in grand prix racing. The technically inhibiting effect of the new formula is exemplified by the fact that it prohibits exploitation of the weight saving made possible by current developments in design and materials. There is wide international support for the belief that recent decisions by the FIA's Commission Sportive Internationale (sporting committee) have not been in the best interests of motor racing throughout the world.

The SMMT fully support these decisions and have asked the Royal Automobile Club, who represent Great Britain on the FIA, to bring the urgent attention of that body to the disastrous effect on all motor sport which will result unless immediate action is taken to enable racing to continue in a form which will have the support of the important majority of the industry throughout the world.

Hence, unless either the CSI or the British motor racing interests climb down, grand prix motor racing in 1961 will most probably see only two teams of cars, the Ferraris and the Porsches. Just these two teams together would find it very difficult to get either public support or support from the race promoters who, presumably, like to run their races on an economic basis. It is unlikely that Formula 1 motor racing could continue under these circumstances.

Equally it is unlikely that either of the two contending bodies will give in completely to the demands of the other. Hence a compromise solution to the problem is the most likely answer—the most probable being for cars of 1,500 c.c. with no weight restrictions. This would permit the current British Formula 2 cars, which are already of 1,500 c.c. capacity but weigh quite a bit under 500 kg, to take part in grand prix racing in 1961.

Larger Volkswagen and Bigger Porsche on the Way

A new outbreak of rumours in the German press, concerning a new, modern Volkswagen with Italian styling was no more true and no more false than many similar rumours over the last five or six years. VW, looking to the day when its durable beetle-backed design sinks into obsolescence have built several prototypes, some with smaller engines than the present one, and some more powerful. Ghia, who did the famous Karmann Ghia coupe and convertible, has submitted body designs for new VW sedans and other top Italian designers are also believed to have produced designs.

These preparations have gone on in great secrecy while Dr. Heinz Nordhoff, VW's managing director, maintained a bland unruffled exterior and announced that the next million VWs would look very like the previous million. But this time the market climate has demanded a more flexible line. It is admitted that the possible introduction of an additional model is under consideration, but no decisions are said to have been taken. Having just announced that production of the present range is to be increased in stages from 3,000 to 4,000 a day during this year, by a new plant investment of £42 million, VW management could not afford to risk having sales fall off while buyers waited for a new model. It seems likely that the present car will continue with further detail improvements for at least a year or two.

Dr. Nordhoff admitted at the Geneva Show that an increase in engine size is among future possibilities. He added "VW which ten years ago made 90,000 automobiles, had increased this in 1959 to 697,000 VW passenger cars and transporters and is planning a total production of 817,000 in 1960. 180 designers have been working for the last 12 years to improve still further the Volkswagen's value as a car. Nothing could be further from our minds than to bedevil our whole programme of improvement by introducing a completely new design without due care and consideration. I know that the evergreen question of whether there will be a new Volkswagen will be arising again and I give the same answer that I gave years ago. I said then that the three-millionth Volkswagen would look just about the same as the two-millionth. We are now coming to the fourth million, but the firm's policy remains the same and will continue to do so."

He then went on to admit that the policy might change if public interest declined or if technical advances production to a solution so superior to the present type that it could not be ignored. Reports from Germany indicate that the long waiting lists for new cars are at last dwindling.

Clues to the engine size of the new model came from Nordhoff's analysis of the United States market. He said, "The VW has its place in the American market—now 3·8 per cent—and this place will be held. Between the new American models with engines from 2 to 2·5 litres capacity and priced over rather than under $2,000 and the typical European small cars in the 1 litre class priced at about $1,600 there exists a difference of a whole range of classes. The compact cars are selling at the expense of the conventional Fords, Chevrolets, Plymouths, and even further up the scale, and not from the small cars."

A new roomier VW, with bigger luggage space, and an engine of around 1,600 c.c. (a size already used successfully by Porsche) would therefore fit nicely into home and export markets, coming between the existing model and the successful American compacts. Meanwhile, Porsche too have plans for a larger car, a full four-seater aimed to meet the American demand for a family sports car. Rumours say a new flat six engine of 2·4 litres has been developed for it, using cylinder and valve assemblies derived from the existing fours.

Even Smaller Reactors

DOING it the big way as usual, the American small reactor programme fills the spectrum of power output from watts to power station size. The comprehensive development programme divides into three sections, each with its own backing, purpose, and solution. The sections are small power reactor prototypes, army package power plants, and auxiliary power sources for space vehicles and isolated meteorological and radiation recording stations.

Small Prototypes to Save on Cost

Although the Americans have learned to live with the fact that nuclear power is not now competitive, both the public, represented by the Joint Congressional Committee on Atomic Energy, and the USAEC are convinced that a nuclear power programme is essential for the country's future safety and prosperity. Under such conditions neither a full scale power programme, nor complete stoppage of development work on nuclear power is justifiable. The compromise solution resulted in the birth of the Power Demonstration Program of the USAEC, in which the Government is subsidising civilian power reactor projects. To keep the costs and operating losses as low as possible, the reactors constructed under the project have power output limited to the 10 to 75 MW(e) range. Further operating economies result from using the reactor plant simply as a steam source for the turbines of a conventional station, such as at Piqua City. Not only the turbo-generating plant, but distribution gear, maintenance, staff facilities, and the site are shared. Reactors built under the power demonstration programme are not true "small reactor stations," they are simply advanced small scale models of the big power reactors of the future.

Military Power Plants

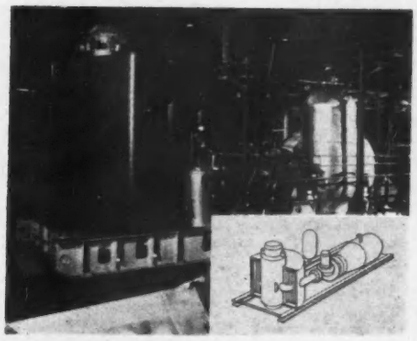
True small reactor development in America is handled by the services. Pioneered by the Navy's submarine reactors, both the Army and the Air Force have since entered the field with reactors ranging up to 10 MW electrical output. The demand for military nuclear power is clear cut: both the Army and the Air Force operate installations with a large power demand remote from conventional sources of fuel. In peace-time even the services must watch expenses, and radar stations of the Distant Early Warning system in the Canadian North, and the Air Forces bases in Greenland and the Pacific islands operate in areas of abnormal fuel cost. And in war-time the problem of fuel supply is acute. In addition the Army would like to see a reactor plant developed that could be fitted into a small barge or a trailer as a mobile power source independent of fuel lines. In its development programme the US Army distinguishes three classes of mobility: stationary plants denoted by the code letter S, portable plants, usually modular, denoted by P, and mobile plants with code letter M. The major effort has so far been concentrated on the P-series, and S-series below 10 MW, leaving larger plants to the civilian programme. Fully mobile M-series plants will be based on gas-cooled reactors using direct cycle gas-turbines. Aerojet-General's nitrogen cooled proposal was described in Atomic Review, 18 December, 1959.

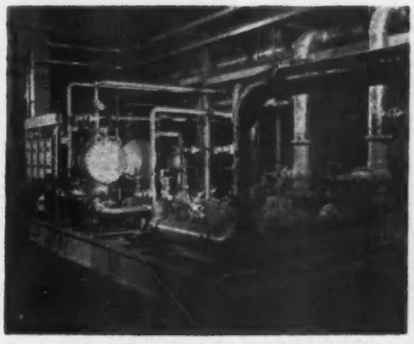
Stationary to Portable

Both Martin Nuclear and Alco Products are working on portable modular stations for the Army and the Air Force. Martin's PM-1 (M stands for "medium power") was described in Atomic Review, 1 April, 1960, and will be operated by the Air Force at Sundance, Wyoming. Alco Products have designed and constructed the medium power stationary plants SM-1, operating since 1957, and SM-1A, now under construction at Fort Greely, Alaska. The design experience gained with the two stationary models has been adapted by Alco to a package plant. Under the designation PM-2A, this plant will be flown to Greenland and installed in the Camp Century military base. The political manoeuvres between the US and Danish governments were completed last May 22, and the skid-mounted reactor packages are now ready for shipment. Fig. 1 shows the reactor and primary heat exchanger package. The pressurised water reactor core develops 10 MW(t), providing 1·56 MW of electricity and one million Btu per hour of steam for space heating. Fig. 2 shows a typical component package—the feed water heating plant—mounted on heavy welded skids and assembled for acceptance testing in Alco's workshops at Dunkirk, NY, prior to delivery to Camp Century.

Increased Core Rating

To accelerate the development programme and cut costs, components from the SM series were freely adapted. The fuel elements are identical; and the cores are similar, with the exception that eight corner elements have been removed. The performance of the SM fuel elements proved to be highly satisfactory and the reduction in core size has been counteracted by an increase in the rating. The slight reduction 20·16 in instead of 22·24 in, in core diameter, has resulted in a considerable decrease in pressure vessel size, the total reduction being 10¼ in on the diameter. Similarly, the control mechanisms were taken directly from the SM-1 design. Control is through variable core geometry: there are 32 stationary and 5 movable fuel elements used for control. The complete power plant consists of 27 packages with maximum 15 ton weight and designed to fit inside standard military cargo planes of the C-130 class or larger. At Camp Century the station will be installed in snow tunnels as shown in Fig. 3. Owing to the extreme cold the condensers of the turbine operate on ethylene glycol antifreeze instead of water in a closed, air-cooled cycle. The plant will be in operation by September.





Space Auxiliary Systems

At the very bottom of the range of small power reactors are the space auxiliary plants developed by Martin Nuclear and Atomics International. Although the initial development was sparked by the demand for a light durable power source for space vehicles and satellites, the systems may find application in unattended radar installations and weather stations. Two entirely different systems have been evolved. Martin Nuclear pioneered the thermoelectric converters using the decay heat of radioactive isotopes as source (Atomic Review, 22 January, 1960). The approach of Atomics International was quite different: they built a self-contained miniature power plant using a more or less conventional vapour cycle (Atomic Review, 18 December, 1959). The advantage of the latter approach is that the total power output of the plant is less limited, and could be increased into the megawatt range. Dr. Chauncey Starr, vice-president of North American Aviation, parent company of Atomics International, argues that the electrical power requirements of airborne systems have a habit of spiralling upwards from the first estimates of a conceptual study. For instance the requirements of the B-52 bomber increased three-fold between the initial concept and the operational version. By the time a project matures, the original auxiliary power system turns out to be inadequate and has to be doubled or tripled. But solar or decay heat converters have certain physical limitations which make it difficult to extend their use into the megawatt range. It may be the difference between Russian and American design philosophy: the Russians put the necessary hardware together to complete a space mission, including the booster rockets; while the Americans trim down their missions to suit the available hardware.

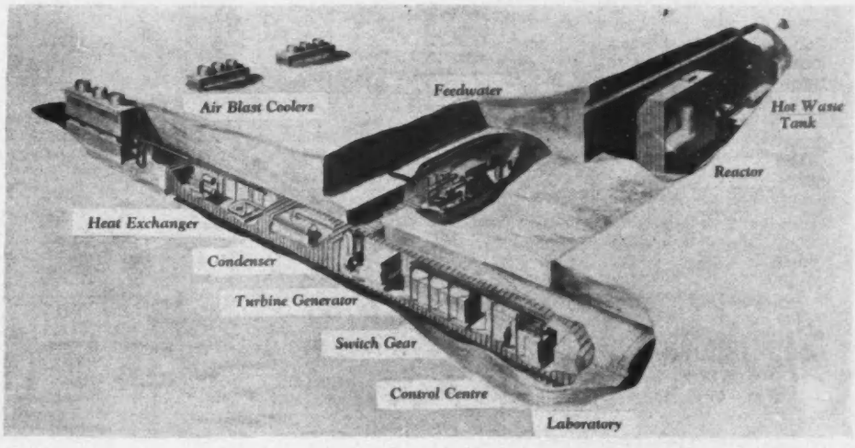
The Competitors

The chief competition in a future market for small reactors is not likely to come from the power-reactor demonstration programme: these are scaled-down versions of big plants designed to gain experience and test the performance. The threat to British small reactor interests will come from stations specifically designed to operate reliably in isolation from extensive power grids, and without the benefit of expert staff and fancy maintenance—the army package reactors and large-scale versions of space auxiliary power systems.

Fig. 1 (top) Reactor and primary heat exchanger package of the Alco portable reactor plant, ready for shipment to Greenland. Inset shows cutaway view of reactor shield, pressuriser and primary heat exchanger.

Fig. 2 (left) Feed water plant, mounted on a separate skid. Complete skid units will fit in a C-130 cargo plane.

Fig. 3 (below) Layout of the Camp Century nuclear plant in Greenland, housed in tunnels dug in the snow. The plant will supply 1½ MW power and 1 million Btu per hour of heat.



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Fuel:
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Composition: (powder, pellet, fuel-moderator mixture)
Enrichment:
Form: (plate, rod, etc.)
Cladding material:
Availability:
(based on an estimate of scheduled maintenance and fuelling time requirements, per cent of operating time)
Design life:
Whole plant:
Reactor core:
Generating equipment:

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Proposed Reactor:		
Prototype design		
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Description of operating experience with working prototype or alternative application (e.g. marine reactor, etc.);
Earliest possible commissioning date of complete power reactor
(1) at a site in UK
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Method of power generation:
(steam turbine, gas turbine, etc.)
Description of plant:
(steam or gas conditions, conditions of heat rejection, extraction stages and economisers, turbine speed, thermal efficiency, etc.)
Deviation from normal power generation practice:
(steam wetness, moisture removal, non-standard generator size, shielding, type of bearing, shaft seal, etc.)
Heat rejection:
(cooling tower, dry cooling tower, river, seawater, etc.)
Quantity of cooling water:
(or cooling water makeup of dry tower)
Cooling water inlet and outlet temperature:

D. Reactor Core

Overall dimensions and weight:
Core materials:
(materials in contact, material compatibility at operating temperature, etc.)
Description of core:
(number and direction of channels, coolant flow direction, temperature at inlet and outlet, method of flow regulation in channels, central channel rating, degree of flux flattening, method of flattening, reflector, heat transfer, maximum heat flux, burnout flux, core structure and support, etc.)
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Fuel inventory:
Average burnup at equilibrium and first load:
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Fuel handling and storage:
Shielding:
Maintenance: (possibility of replacement, inspection, access, etc.)
Containment (if any):

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Site requirement:
Size and construction of reactor building:
Reactor building crane, capacity and span:
Turbine hall dimensions:
Turbine hall crane, capacity and span:

G. Economic Analysis

Capital cost of plant in home country:
Capital cost of first fuel load:
Capital charges, based on 5½ per cent interest and 70 per cent utilisation:
Fuel cycle cost:
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B&W — 60 MW PWR

By T. B. Webb

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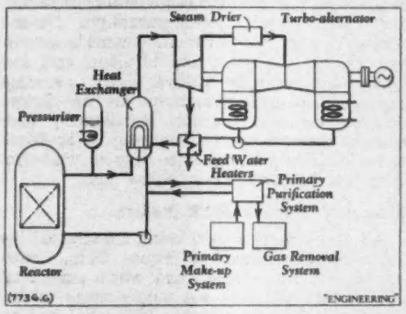
Babcock and Wilcox Limited have long enjoyed full technical cooperation with the Babcock and Wilcox Company of America in the design and construction of conventional power plant. More recently, following the signing of the US-UK bilateral agreement in 1955 for cooperation in the development of the peaceful uses of atomic energy, the cooperation between the two companies has been extended to include nuclear power generation. The immediate result of this has been the development by the British company



of a range of reactors of the pressurised water type, similar in principle to those being built by the Babcock and Wilcox Company for Consolidated Edison at Indian Point, near New York, and for the NS SAVANNAH, the first commercial nuclear ship. The bases of design of the wholly nuclear parts of the steam raising plant are developed jointly by the two companies and draw heavily upon the work carried out by the American company in their critical facility and nuclear fuel factory at Lynchburg, Virginia.

Tested on Land and in Ships

The pressurised-water reactor has up to the present time formed the exclusive basis of the propulsion plant for all nuclear ships built or currently building and, since the power required by most ships is relatively small, the marine field has been an ideal "proving ground" for the smaller reactors capable of adaptation to land-based application. The system has accumulated much satisfactory experience both in construction and operation. It is simple, straightforward and rugged in character, its construction representing little extrapolation in the traditional manufacturing methods with which the heavy engineering trades are conversant. It does not require special materials except, in common with all other reactor types, in the core itself. Its inherent safety and controllability have been established under difficult conditions of operation calling for rapid load changes, such as manoeuvring at sea, and for utmost reliability, for example in the submarine polar voyages. The durability of components has been good, no doubt because the working medium is ordinary water about which so much is known.

Advantages of Water Cooling

The plant is compact and readily accommodated in a safety containment structure such as a spherical pressure vessel, so that even in case of the maximum credible accident harmful radioactive products are completely contained. Problems of finding suitable sites near the load centres are thereby simplified. Under normal conditions of operation, carry-over of radioactivity into the turbines or elsewhere cannot take place and no special problems whatever arise in routine maintenance in the turbine house. Maintenance tasks inside the reactor area are permissible within minutes after shut-down since the water coolant of the reactor does not impart long-lived radioactivity to the various components like pumps and valves in the primary circuit. The pressurised-water system is, of course, essentially a closed circuit comprising the reactor, heat exchangers and pumps and some important advantages accrue: accurate control of water condition is possible, ensuring corrosion-free operation, including, for example, the maintenance of hydrogen overpressure in the system; faulty fuel elements can be tolerated within the liberal capability of the coolant clean-up system which deals with escaping fission products; plutonium enrichment can be used, and so on. The economics of operation of nuclear generating stations spring basically from capital cost and fuel cost, two factors which, in the case of the pressurised-water reactor, are known with relative certainty because of extensive prior construction and operation.

Description of the Plant and Auxiliaries

The reactor uses uranium dioxide in pellet form enriched to 2·4 per cent in the fissile isotope. The core is housed in a heavy pressure vessel 9 ft 0 in internal diameter and 7½ in thick, with demountable closure and coolant inlet and outlet branches connecting the reactor to the four heat exchangers. The twenty-one control rods, with electromagnetic drives mounted on the head of the reactor pressure vessel, provide ample control over reactivity under all possible conditions of operation. The four heat exchangers are of the shell and tube type with coolant flowing through the tubes. The shell sides produce saturated steam at 675 lb per sq. in which is led to a 65 MW turboalternator having four stages of feed-heating with full deaeration. The power consumption of the station is 4 MW, of which 2 MW is taken by the reactor coolant circulators. The turbine has a single stage of moisture extraction between the high and low pressure cylinders.

An ancillary circuit is provided, the purpose of which is to filter out any solid radioactive matter carried by the coolant in the event of failure of the cladding of the fuel elements. This feature permits the core to continue to run normally at full load even if 5 per cent of the elements have failed, enabling the maximum fuel life to be attained. Fuel replacement necessitates removal of the closure of the reactor pressure vessel, lifting out half the fuel—that in the centre positions of the core—lifting the remainder from the perimeter positions into the centre positions and finally putting new fuel into the perimeter positions. This operation occurs every 2 years if the load factor is 70 per cent and takes about 2 weeks. The availability of the plant as a whole is therefore hardly influenced by this refuelling procedure and is still determined by orthodox periodic overhaul and inspection.

Development Potential of the PWR

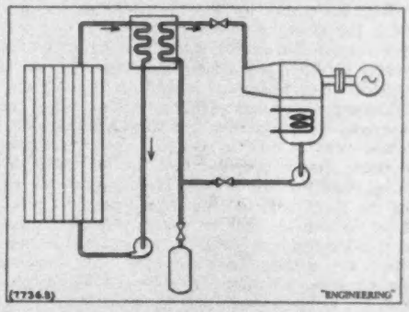
Improvements in nuclear fuel elements will continue to be the outcome of operational experience and it is confidently expected that the temperature of the coolant in future designs of pressurised water reactor will rise on two accounts Firstly, the margin of subsaturation will be decreased, the coolant then being at the saturation temperature corresponding to the pressure and, secondly, the pressure itself will be raised. The foreseeable thermal efficiency of these land-based stations is over 35 per cent. Of greater importance still is the applicability of the "moderator control" principle which is based upon mixing a certain amount of heavy water with the ordinary water in the coolant system. This enables excess reactivity to be built into the core and very long fuel life to be achieved. As the core is burnt, the fraction of heavy water is decreased until, towards the end of the core's life, the reactor is working with only ordinary water in the orthodox manner. Savings in capital and fuel costs are likely to be appreciable and are the result of better neutron economy, improved conversion ratio, lower power peaking factors and longer fuel lifetime.

DH — 16 MW HTGCR

By G. E. Preece

De Havilland Engine Company

The reactor studies carried out by the nuclear power group of the de Havilland Engine Company have been exclusively concerned with the design of compact highly rated systems with maximum power outputs in the range 5 to



30 MW(e). This size range corresponds to the requirements for both small independent power generating stations and marine craft so that it is logical to consider the same basic reactor design for both applications although the important differences in requirements should be recognised. The prime objective of low generating cost consistent with safe operation can only be achieved if careful consideration is given to the following.

(1) A high volumetric heat rating for the core is essential in order to reduce the reactor size and hence the capital cost of the plant.

(2) Site preparation must be reduced to an absolute minimum. An attractive concept would be to mount the main sections of the plant containing the reactor boiler unit, the steam turbo-alternator set, and the control room on separate rail cars so that an existing railway siding might be used as a base. This would also greatly facilitate the transport of the reactor to the site and subsequent replacement of any unit for fuel changing or maintenance at a central depot.

(3) Simplified shield concepts employing locally available materials must be examined. A short length of prefabricated concrete tunnel covered with earth, might be adequate.

(4) The plant should be semi-automatic in operation such that a staff of about three should suffice on duty.

(5) Frequent refuelling or fuel element shuffling in the reactor should not be necessary since these operations require the services of skilled personnel and higher operating costs inevitably result.

(6) Special reactor equipment for refuelling and maintenance should be provided by a central depot to service a number of identical reactors.

(7) The steam generated in the boilers should be usable in conventional steam turbine plant since it may be necessary to use the nuclear boilers in parallel with existing installations.

Fuel and Core

Bearing in mind these broad aims, the de Havilland Engine Company have so far concentrated their attention exclusively on the design of the high temperature gas cooled reactor (HTGCR) since the basic characteristics of this

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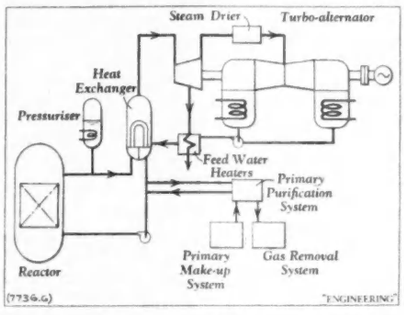


of a range of reactors of the pressurised water type, similar in principle to those being built by the Babcock and Wilcox Company for Consolidated Edison at Indian Point, near New York, and for the NS SAVANNAH, the first commercial nuclear ship. The bases of design of the wholly nuclear parts of the steam raising plant are developed jointly by the two companies and draw heavily upon the work carried out by the American company in their critical facility and nuclear fuel factory at Lynchburg, Virginia.

Tested on Land and in Ships

The pressurised-water reactor has up to the present time formed the exclusive basis of the propulsion plant for all nuclear ships built or currently building and, since the power required by most ships is relatively small, the marine field has been an ideal "proving ground" for the smaller reactors capable of adaptation to land-based application. The system has accumulated much satisfactory experience both in construction and operation. It is simple, straightforward and rugged in character, its construction representing little extrapolation in the traditional manufacturing methods with which the heavy engineering trades are conversant. It does not require special materials except, in common with all other reactor types, in the core itself. Its inherent safety and controllability have been established under difficult conditions of operation calling for rapid load changes, such as manoeuvring at sea, and for utmost reliability, for example in the submarine polar voyages. The durability of components has been good, no doubt because the working medium is ordinary water about which so much is known.

Advantages of Water Cooling

The plant is compact and readily accommodated in a safety containment structure such as a spherical pressure vessel, so that even in case of the maximum credible accident harmful radioactive products are completely contained. Problems of finding suitable sites near the load centres are thereby simplified. Under normal conditions of operation, carry-over of radioactivity into the turbines or elsewhere cannot take place and no special problems whatever arise in routine maintenance in the turbine house. Maintenance tasks inside the reactor area are permissible within minutes after shut-down since the water coolant of the reactor does not impart long-lived radioactivity to the various components like pumps and valves in the primary circuit. The pressurised-water system is, of course, essentially a closed circuit comprising the reactor, heat exchangers and pumps and some important advantages accrue: accurate control of water condition is possible, ensuring corrosion-free operation, including, for example, the maintenance of hydrogen over-pressure in the system; faulty fuel elements can be tolerated within the liberal capability of the coolant clean-up system which deals with escaping fission products; plutonium enrichment can be used, and so on. The economics of operation of nuclear generating stations spring basically from capital cost and fuel cost, two factors which, in the case of the pressurised-water reactor, are known with relative certainty because of extensive prior construction and operation.

Description of the Plant and Auxiliaries

The reactor uses uranium dioxide in pellet form enriched to 2·4 per cent in the fissile isotope. The core is housed in a heavy pressure vessel 9 ft 0 in internal diameter and 7½ in thick, with demountable closure and coolant inlet and outlet branches connecting the reactor to the four heat exchangers. The twenty-one control rods, with electromagnetic drives mounted on the head of the reactor pressure vessel, provide ample control over reactivity under all possible conditions of operation. The four heat exchangers are of the shell and tube type with coolant flowing through the tubes. The shell sides produce saturated steam at 675 lb per sq. in which is led to a 65 MW turboalternator having four stages of feed-heating with full deaeration. The power consumption of the station is 4 MW, of which 2 MW is taken by the reactor coolant circulators. The turbine has a single stage of moisture extraction between the high and low pressure cylinders.

An ancillary circuit is provided, the purpose of which is to filter out any solid radioactive matter carried by the coolant in the event of failure of the cladding of the fuel elements. This feature permits the core to continue to run normally at full load even if 5 per cent of the elements have failed, enabling the maximum fuel life to be attained. Fuel replacement necessitates removal of the closure of the reactor pressure vessel, lifting out half the fuel—that in the centre positions of the core—lifting the remainder from the perimeter positions into the centre positions and finally putting new fuel into the perimeter positions. This operation occurs every 2 years if the load factor is 70 per cent and takes about 2 weeks. The availability of the plant as a whole is therefore hardly influenced by this refuelling procedure and is still determined by orthodox periodic overhaul and inspection.

Development Potential of the PWR

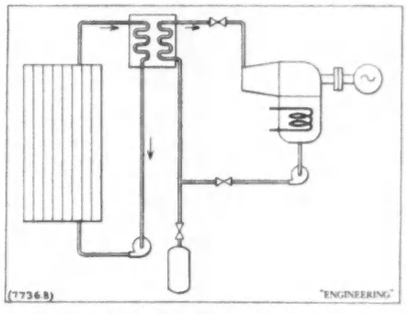
Improvements in nuclear fuel elements will continue to be the outcome of operational experience and it is confidently expected that the temperature of the coolant in future designs of pressurised water reactor will rise on two accounts Firstly, the margin of subsaturation will be decreased, the coolant then being at the saturation temperature corresponding to the pressure and, secondly, the pressure itself will be raised. The foreseeable thermal efficiency of these land-based stations is over 35 per cent. Of greater importance still is the applicability of the "moderator control" principle which is based upon mixing a certain amount of heavy water with the ordinary water in the coolant system. This enables excess reactivity to be built into the core and very long fuel life to be achieved. As the core is burnt, the fraction of heavy water is decreased until, towards the end of the core's life, the reactor is working with only ordinary water in the orthodox manner. Savings in capital and fuel costs are likely to be appreciable and are the result of better neutron economy, improved conversion ratio, lower power peaking factors and longer fuel lifetime.

DH — 16 MW HTGCR

By G. E. Preece

De Havilland Engine Company

The reactor studies carried out by the nuclear power group of the de Havilland Engine Company have been exclusively concerned with the design of compact highly rated systems with maximum power outputs in the range 5 to



30 MW(e). This size range corresponds to the requirements for both small independent power generating stations and marine craft so that it is logical to consider the same basic reactor design for both applications although the important differences in requirements should be recognised. The prime objective of low generating cost consistent with safe operation can only be achieved if careful consideration is given to the following.

(1) A high volumetric heat rating for the core is essential in order to reduce the reactor size and hence the capital cost of the plant.

(2) Site preparation must be reduced to an absolute minimum. An attractive concept would be to mount the main sections of the plant containing the reactor boiler unit, the steam turbo-alternator set, and the control room on separate rail cars so that an existing railway siding might be used as a base. This would also greatly facilitate the transport of the reactor to the site and subsequent replacement of any unit for fuel changing or maintenance at a central depot.

(3) Simplified shield concepts employing locally available materials must be examined. A short length of prefabricated concrete tunnel covered with earth, might be adequate.

(4) The plant should be semi-automatic in operation such that a staff of about three should suffice on duty.

(5) Frequent refuelling or fuel element shuffling in the reactor should not be necessary since these operations require the services of skilled personnel and higher operating costs inevitably result.

(6) Special reactor equipment for refuelling and maintenance should be provided by a central depot to service a number of identical reactors.

(7) The steam generated in the boilers should be usable in conventional steam turbine plant since it may be necessary to use the nuclear boilers in parallel with existing installations.

Fuel and Core

Bearing in mind these broad aims, the de Havilland Engine Company have so far concentrated their attention exclusively on the design of the high temperature gas cooled reactor (HTGCR) since the basic characteristics of this

type make it extremely attractive for the application. A typical design which has been examined in some detail is that submitted to the Galbraith Committee for ship propulsion. This could be used in conjunction with a conventional steam turbine designed for steam conditions of 600 lb per sq. in and 850° F and would have a net electrical output of 16 MW.

The reactor core comprises an assembly of graphite blocks containing the fuel in the form of uranium and thorium carbide and dispersed in graphite pellets. An impermeable graphite would be used for both the pellets and the blocks in order to minimise the escape of gaseous fission products from the fuel. Helium gas at 50 atmospheres pressure is pumped through a large number of coolant holes in the core and transfers the heat produced to six boiler units projecting above the reactor pressure vessel. The use of an all-ceramic core permits safe operation at temperatures in excess of 1,000° C (1,832° F) and the large temperature difference between the fuel and steam results in a high core heat rating, small boiler size, and low pumping power loss.

Compact Layout

The integration of the boiler-circulator units with the pressure vessel results in a compact plant layout and enables a secondary containment vessel to be fitted inside the main biological shield. No additional shielding is necessary therefore to protect against leakage into the secondary containment. A laminated iron and water shield is used to reduce weight which also acts as a tertiary containment vessel. Calculations show that in the event of a complete failure of the coolant system the decay heat produced after shut-down will be adequately transferred to the surrounding structure by conduction and radiation without an excessive rise in core temperature, although further study and experimental work is required to prove this point beyond doubt.

Dispersal Aids Fuel Life

It is predicted that refuelling will be necessary at intervals of not less than four years and there is strong evidence to suggest that much longer periods of operation may be realised. This results from the good conversion factor and the superior nuclear qualities of the uranium 233 produced with this system. Radiation damage to the fuel is greatly reduced by the dilute dispersion of fuel in the graphite matrix.

Economics

Preliminary estimates indicate that the cost of the reactor boiler unit in this size might not exceed £44 per kW for small production batches and it should be possible to build the complete plant for about double this figure if the approach suggested in the foregoing is followed. The fuel cost for this reactor when operating at 70 per cent load factor is expected to be in the region of 0·28*d* per kWh at US price levels so that the overall generating cost will be very competitive with conventional plant particularly in areas of high conventional fuel cost. Improved designs employing beryllia cores of smaller diameter are currently being investigated and these appear to be even more attractive since reductions in plant size, weight and cost may be possible.

EE — 11 MW OMR

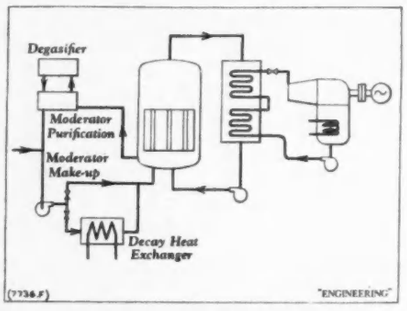
By Dr. H. S. Arms

English Electric Company

In May, 1959, the English Electric Company entered into a licence agreement with the Atomics International Division of North American Aviation Incorporated, which also provided for the exchange of information on the organic moderated reactor system. Atomics International are the world's leading experts in this type of reactor, in the development of which they continue to receive strong support from the US Atomic Energy Commission. The system is very simple and essentially comprises a mild steel vessel containing a lattice of uranium fuel rods suitably clad, and through which an organic hydrocarbon compound is pumped. A nuclear chain reaction in the fuel rods occurs in the presence of the organic moderator. The heat produced is removed by the organic coolant which is then passed through a simple shell and tube heat exchanger to produce steam. The organic liquid is finally pumped back to the reactor vessel for further heating in the core.

Dual Function of the Organic Liquid

The moderating properties of a hydrocarbon are mainly due to the presence of the hydrogen atoms in the organic molecule. Hydrogen has higher capture cross section than carbon, hence a hydrogen system is more compact than a graphite system, but some enrichment of the fuel is necessary to compensate for loss in the moderator. Heavy water gives a better neutron economy but it is very expensive; and in any case the average total distance travelled by a neutron during its lifetime in a heavy-water reactor is of the same order as in graphite, so



the system is almost as bulky. Another disadvantage of water moderation is the oxygen reaction with fast neutrons giving an undesirable degree of radioactivity. A hydrocarbon moderator containing the highest possible amount of hydrogen is desirable, since the latter element is responsible for nearly all the moderating properties of the compound, the carbon in the molecule acts mainly as a carrier for the hydrogen. The organic moderator should develop little induced radioactivity. In order to examine the feasibility of this reactor concept, an organic moderated reactor experiment was constructed at the National Reactor Testing Station in Idaho, and has now been operating successfully up to a maximum of 16 MW thermal power for over two years. The experiment has yielded valuable data on the behaviour of certain organic compounds under irradiation. Operating experience has enabled the extent of irradiation damage to the organic compounds to be evaluated, an effect which produces heavy polymers or long chain molecules which tend to have a detrimental effect upon the heat transfer properties of the coolant. These high boiling point residues must be removed continuously and replaced with fresh coolant. The rate of coolant make-up is of the order of 1 lb per thermal MWh of operation.

Advantages of Organic Moderator

The organic compounds employed are polyphenyls. The commercial compound in current use is Santowax R, a mixture of terphenyls, which is a soft waxy substance at room temperature. It is necessary therefore to pre-heat the reactor and primary coolant loop above the melting point of the organic moderator-coolant when the system is not operating at nuclear power. The very considerable advantages of the OMR can be summarised as follows:

1. The low vapour pressure of the compound in the 600 to 800° F range gives low operating pressures in a heat cycle giving reasonable steam conditions. There are no pressure vessel problems as with water moderated reactors.
2. The use of one material as a combined moderator and coolant reduces the size of the core very considerably.
3. The compound is chemically compatible with cheap materials, such as carbon steel and aluminium, and its reaction rate with water and uranium is also very slow.
4. The degree of radioactivity imparted to the coolant is very low, which means that not only is there a considerable saving in shielding materials but it is also possible to do a limited amount of maintenance work on a shut down coolant loop, the reactor operating at reduced power.
5. Low operating pressures and low radioactivity levels eliminate the need for expensive containment structures. Corrosion rates are low.
6. Fluid moderator-coolant gives a large negative temperature coefficient of reactivity.

Capital Costs and Generating Costs

In view of the economies introduced by the features listed above, it is possible to construct OMR nuclear power stations by established conventional engineering techniques with standard items of equipment and low cost materials. However, the comparatively late start of the engineering of OMR's compared with other reactor systems has resulted in a good deal of conservatism being inherent in current designs. For the time being therefore the overall simplicity and economy of the OMR is not entirely reflected in the present costs of power generation. Nevertheless, considerable potential increases in output are present in a given size of plant, and are almost certain to be realised when operating experience permits relaxations in the design margins on heat transfer calculations, fuel element temperatures and burn-up in addition to anticipated economies in organic make-up costs and fuel element fabrication costs.

Present Progress in OMR Projects

An OMR plant is now being constructed by Atomics International at Piqua, Ohio, under contract to the USAEC, and when completed late in 1961 the plant will supply steam to the existing municipal station. The AEC is also sponsoring the design of an experimental organic cooled reactor for installation at the NRTS in Idaho. This plant is also planned for completion late in 1961 and will provide facilities for advanced development work on such features as irradiation characteristics of organic compounds, fuel element performance and core physics. Engineering work will be carried out by the Fluor Corporation with Atomics International as subcontractors for the nuclear portion of the plant and its auxiliaries. A further AEC project will be the construction of a complete prototype OMR nuclear power station in excess of 50 MW electrical output. American electrical utilities are being invited to submit suitable proposals to the AEC during the next few months. Interatom, the associated company of Atomics International in Germany is at present engaged upon a study for a nuclear ship of 10,000 shaft horse-power. Finally, the British Ministry of Transport has recently called for tenders for a 20,000 s.h.p. nuclear propulsion unit incorporating either a boiling water reactor or an organic moderated and cooled reactor to be installed in a 65,000 tons deadweight tanker. English Electric will be putting forward a proposal for a propulsion unit based upon the OMR.

GEC — 30 MW GCR

By M. Lindfield

GEC—Simon-Carves Atomic Energy Group

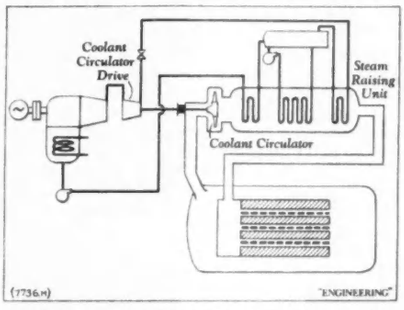
The GEC—Simon-Carves Atomic Energy Group is now developing its advanced type of gas-cooled reactor for use in electricity generating stations in the range 20-100 MW(e). This account describes a 30 MW(e) installation, the first step in the adaptation for land use of an earlier marine reactor. The reasons for the choice of a gas-cooled graphite-moderated system can be briefly summarised as follows.

This system is the most extensively applied and thoroughly understood of any in the application of nuclear energy to power-station re-

quirements. The UK Atomic Energy Authority's Advanced Gas-cooled Reactor will extend operating experience to uranium-oxide fuel. Operating temperatures are independent of the coolant pressure and the use of oxide fuel canned in stainless steel enables the coolant outlet temperature to be chosen to match modern steam-turbine practice. The development of completely impermeable graphite will soon have reached the stage when it can be considered as a canning material, giving a significant reduction in fuel enrichment and an even greater temperature safety margin. It would also give greater freedom of surface configuration in optimising heat-transfer performance.

Safety and Reliability

Safety and reliability are primarily dependent on the state of development of any system. In addition to advantages inherent in the gas-cooled graphite-moderated system, the use of uranium-oxide fuel eliminates any risk of oxidation by the coolant gas in the event of failure of the can. Moreover, with a containment atmosphere also of carbon dioxide, no fire hazard exists under any foreseeable accident condition. The reactor technology of these materials has been thoroughly



established and neither moderator nor coolant undergoes a temperature-induced change of state. Channel monitoring for fuel-element failures is well established and the problems of on-load charge–discharge have been solved. Using stainless-steel canning, there is a 700° C temperature margin between operating and melting temperatures, and uranium oxide combines a high melting point with temperature stability. In the event of can failure, the turbine is protected from contamination by the barrier of the steam-raising units. Should the primary coolant circuit also fail, spreading of fission products would be prevented by a containment shell.

Reactor Core

The fuel element used is the new GEC cross-flow type, while the moderator and reflector are constructed from hexagonal-section blocks keyed together in such a way that the resulting structure can accommodate both Wigner effects and earthquake loading. The graphite is supported in a steel cylinder, and insulated to reduce temperature gradients.

Reactivity Control

Reactivity control is provided by stainless boron-steel rods driven by electric motors through a chain-type mechanism. In addition a completely independent shut-down system is provided by a second group of boron-steel rods, each driven by high-pressure gas. Rupture of the primary circuit would produce an entirely automatic shut down. The design of control rods permits the changing of mechanisms for maintenance with the reactor on load.

Reactor Pressure Vessel and Primary Circuit

The reactor vessel is a horizontal cylinder with ellipsoidal ends incorporating one standpipe for each fuel channel at the charge end and one for each control channel at the control end. The vessel is designed to be partly fabricated in the workshop so that only two circumferential butt welds are required on site.

Two steam-raising units (SRU) are mounted above and parallel to the reactor vessel, connected to it by gas ducts. The hot gas leaving the fuel channels is led via the hot manifold and ducts to the superheater ends of the SRU's. It passes across the tube banks and returns to the circulators through the annular space between the tube banks and the SRU pressure shell. Each circulator consists of a single-stage centrifugal impeller and diffuser mounted horizontally in the end of the SRU pressure shell. An oil-cooled face seal prevents leakage of coolant gas past the impeller shaft. The circulators are driven by back-pressure steam turbines mounted coaxially with the circulator impeller and exhausting into the main turbogenerator. Variable speed is conveniently provided by throttle governing of the circulator turbine. Electrical transmission and motor losses incurred in any electrically driven system are eliminated. Reactor safety is enhanced since the turbine has no trip, any reactor decay heat being removed by steam generation which in turn is used to drive the circulator.

Fuel Handling

The fuel-handling facilities include new-fuel storage, preparation for charging under super-clean conditions, a shielded charge-discharge machine, a cooling pond for irradiated elements, and provision for decontamination of element transport flasks. All this equipment is sited within the reactor building adjacent to the reactor itself. The charge-machine consists of two similar magazines arranged in tandem inside a pressure vessel, one end of which terminates in a bellows sealing nozzle. Since the machine operates from outside the containment with the reactor on load, it is itself contained in an outer pressure vessel which also has a bellows sealing nozzle. The closed end of the containment vessel houses the charge chain, together with its driving mechanism, drives for the magazines, and position-indicating mechanisms. The whole machine is suitably shielded and is fitted with flexible connections for power, instrument, and gas supplies. An auxiliary circuit ensures adequate cooling of the irradiated elements throughout the discharge procedure. The irradiated elements are passed down a shielded chute into a skip under water in an arm of the cooling pond. The skips are moved within the main pond area by transporter.

Civil Engineering

The whole of the major plant and equipment of the station is housed " under one roof " in a rectangular structure 330 ft (101 m) long and 93 ft (28·4 m) maximum width. This compact arrangement makes for reduction in capital cost, economy in construction, and convenience in operation. All nuclear plant is situated at one end of the station and the generating equipment at the other—the two parts being connected by the central control block. The reactor building is subdivided into normal, restricted, and contamination areas, with suitable change-room facilities. The whole of the reactor hall including fuel-handling facilities is served by a single goliath crane. This arrangement has the advantage that construction of all the plant within this area can be carried out under cover and the crane is then later used for handling the charge machine and spent-fuel flasks. The charge machine can also be used in the servicing of control-rods. Construction time is estimated to be 31 months.

HS 20 MW OMR

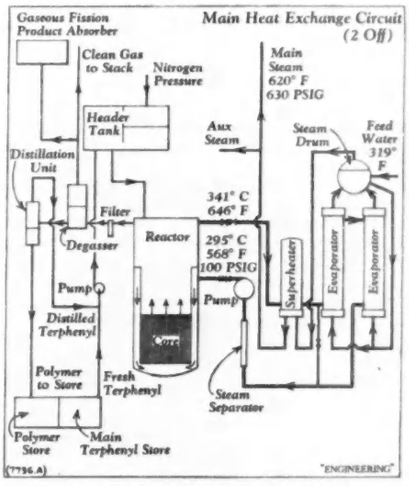
By W. Smith

Hawker Siddeley Nuclear Power Company

The Organic Moderated Reactor has until recently received comparatively little support at the major atomic energy establishments, but in the last few years more people have come to realise its potentialities, and with its selection by the Ministry of Transport for further development as a marine propulsion unit, it must now be considered as one of the leading contenders in the small power reactor field. Nuclear power stations of this type with an electrical output as low as 10 MW can be operated without excessively high operating costs. With foreseeable modifications to the reactor plant and fuel elements, it is anticipated that in a few years, small organic moderated nuclear power plants will have lower costs than conventional power stations in the more remote parts of the world. The design proposed by the Hawker Siddeley Nuclear Power Company Limited for a plant having a net electrical output of 20 MW is essentially simple in concept. The liquid coolant and moderator, terphenyl, which is a derivative of benzene, is non-corrosive and has a low vapour pressure. A system pressure of less than 100 lb per sq. in is required, and mild steel is used in the construction of the reactor vessel and primary circuit. The fuel elements are uranium oxide of 1·7 per cent uranium 235 content in stainless steel cans. Irradiation experience and operating experience of similar element types indicate that these will be reliable. The JASON research reactor at Langley will be used to check the detailed lattice characteristics.

Performance

The normal operating coolant outlet temperature of 341° C (648° F) is below the boiling point



of the terphenyl, which, therefore, will not flash off if a leak develops. The coolant circuit has a very low activity level, arising only from impurities, and the process plant will rapidly reduce activity even from a failed element. The low activity and low pressure ease maintenance considerably. The steam conditions at the turbine stop valve are 600 lb per sq. in, 615° F, and a reasonable wetness fraction is maintained in the last stage of the turbine by the incorporation of a water separator between the high pressure and low pressure cylinders. The core has been designed to be undermoderated, which enables a high conversion factor to be obtained, and together with the high coefficient of expansion of the terphenyl promotes a high degree of reactor stability. The fuel temperature coefficient is always negative, and that of the coolant approximately zero. The moderator coefficient is negative except at high levels of plutonium build-up, but it is ineffective as the temperature excursions are slow in affecting the moderator. Therefore, the transient stability is good. Many operational and failure transient conditions have been checked on the company's analogue computer. The temperature coefficients at high plutonium content are such that the reactor can be fuelled with plutonium-enriched uranium.

Control

The reactor is capable of rapid load changes and can be brought from subcritical to full power in under 3 hours. The load can be brought from 15 per cent to 100 per cent in 15 minutes and vice versa under normal control. Very rapid controlled cut-back without scram is possible (100 per cent to 10 per cent in 30 seconds). The terphenyl is subject to polymerisation by radiation and temperature. The effect

of the polymer is to increase the viscosity and thus the pumping power required. The polymer is extracted by a relatively simple process plant. By designing for a polymer content of 30 per cent and choosing a maximum operating temperature of 341° C the rate of extraction and replenishment is reduced to 100 lb per hour at full power (corresponding to about 0·7 per cent of the fuel consumed in an equivalent oil-fired installation). The fuel elements consist of bundles of 19 fuel rods, which are made up in two sections to permit end to end fuel cycling. Each fuel element is individually supported in the core. Fuel elements can be withdrawn from the pressure vessel into a coffin, and passed out through the bottom of the containment vessel into a cooling pond. At present this is carried out off load but without any dismantling of the reactor. Later designs will incorporate on-load fuel changing with a consequent improvement in economics and operational convenience. The containment vessel is sufficiently robust that no reactor building is required. The primary and secondary shielding will allow normal access to the heat exchangers and coolant circuit for maintenance and inspection, but the reactor will normally be controlled from a small room outside the containment adjacent to the turbine hall.

Safety

A very detailed study of the safety aspects of the OMR design has been undertaken, and it has shown that the reactor system is likely to meet all the safety requirements which may become mandatory. For example, reactor power excursions under fault conditions have been shown to be self-attenuating with only one exception—unrestricted coarse-bank control rod withdrawal during start-up. Even in this case full power is not reached for 1 hour, which gives ample time for corrective action. The limits of combustion of terphenyl are narrow and chances of fire are very small.

Developments

The feasibility of the design presented does not depend on any novel features requiring extensive development and has potentialities for further developments to increased rating, and smaller or larger outputs with economic savings. Such materials as beryllium or sintered aluminium powder might be used to can the fuel, and when their use is proven they could reduce the enrichment required considerably. Coolant make-up costs are likely to fall, due both to reductions in replacement cost and in the damage rate. It is also expected that plutonium enrichment of natural uranium fuel will prove satisfactory for this type of reactor. This should lead to a substantial reduction in costs. On-load fuel handling will further reduce costs by permitting a greater utilisation of the plant and by reducing the enrichment needed to allow for reactivity variations with burn-up. Present indications are that a typical 20 MW power station built in the United Kingdom would cost about £2,200,000 with an additional £1,100,000 for the first fuel load. The net generating cost based upon 5½ per cent interest and 70 per cent utilisation, less insurance, labour and maintenance, is estimated at 0·86*d* per kW hour. Generating costs are, of course, reduced for plant of larger unit capacity, and it is estimated that for a plant of 60 MW electrical output the corresponding net generating cost would be 0·65*d* per kW hour.

H&G — 20 MW PWR

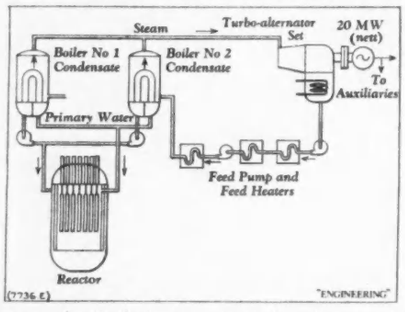
By H. S. Prosser

Humphreys and Glasgow

The activities of Humphreys and Glasgow Limited in the field of nuclear power have been characterised by the treatment of reactors as a means to an end rather than as an end in themselves—the end in this case being the generation of electricity or of process steam as a commercial operation at as low a price as possible compatible with reliability and safety in operation. This philosophy, coupled with the restriction of activities to small power stations, has, at the present state of the art, inevitably led to the choice of the pressurised water reactor as the heat source for the power station—inevitably because this is the only small reactor which at present has a sufficiently broad and prolonged experience to justify its selection for a commercial plant operable by engineers without much special training and with an accurately predictable production cost. Experience commenced with the launching as long ago as 1955 of the submarine Nautilus, which proved to be the successful forerunner of a fleet of over 30 similar vessels. Concurrent with this development has been the building of pressurised water reactors for such varied applications as the Shippingport power station, the Russian ice-breaker Lenin and the American merchant ship Savannah. The reactor for this merchant vessel was designed and built by the Babcock and Wilcox Company of America who are associated with Babcock and Wilcox Limited of London, who in turn are the designers and manufacturers of the reactor for the Humphreys and Glasgow station.

Application

The station is designed for a net electrical output of 20 MW and is particularly suitable for the commercial generation of electricity in areas



where fossil fuels are expensive—in general where oil costs more than £10 per ton or coal £5 per ton. Alternatively, it has application in countries where resources of thermal or hydro power are likely to be inadequate in the future, so that some premium can justifiably be paid to obtain early experience in the operation and maintenance of nuclear plants.

Reactor Core and Coolant Circuit

The reactor fuel is uranium oxide enriched initially to 2·5 per cent, with light water as moderator and coolant. There are two loops to the primary circuit, in each of which the water is circulated by means of a glandless pump to a vertical boiler and back to the pressure vessel. Pressure in the vessel is maintained by an electrically heated pressuriser. There is the usual provision for continuous treatment of primary water and the disposal of contaminated liquid and gaseous effluents. The neutron flux on the pressure vessel walls is reduced by three thermal shields outside the core. The cylindrical pressure vessel, having a welded hemispherical bottom end, is of carbon steel clad internally with austenitic stainless steel. The top closure is formed by a bolted-on head, the flanges being seal-welded.

There is one boiler in each primary loop, consisting of a heat exchanger with steam separators above. The heat exchanger consists of a nest of U-tubes within a mild steel shell, with the primary water circulating through the tubes via a water box. The tubes are of Inconel or Monel metal and the water box is clad with stainless steel.

The pressure vessel, boilers, pumps and pressuriser are all enclosed within a spherical steel containment vessel 45 ft in diameter, site fabricated by welding. The reactor pressure vessel is shielded laterally by a water-filled tank encased in concrete, and vertically by a water-filled canal immediately over the reactor. A further concrete wall, 4 ft thick surrounds the containment vessel to a height of 36 ft above ground level and protects personnel from radiation when the reactor is in operation.

Fuel Cycle

The core is divided into two zones for the purpose of fuel cycling, an inner zone comprising the central nine elements in a 3 by 3 lattice and an outer zone comprising the remaining 12 elements. In the equilibrium condition 12 new fuel elements first spend one "core life" in the outer zone. At the fuel changing operation, nine of them are transferred to the inner zone, from which the elements are removed for reprocessing together with the three surplus elements from the outer zone. By this means the outer zone is maintained at a higher enrichment than the inner, so producing a more uniform flux distribution than if the whole core were replaced at one time. The estimated period between refuelling operations is 520 days at full power. It follows from the above that at 70 per cent load factor it is only necessary to change fuel about every two years.

Reactor Control and Safety

The pressurised water reactor is characterised by its essentially stable features. While the control rods are automatically operated to follow variations in load, no serious results will ensue should they in fact fail to respond even when full load might be thrown off the main alternator. Provision is included for removing the decay heat after reactor shutdown, even in the unlikely event of complete loss of auxiliary electrical power, and a special dump condenser is not necessary. There are 12 control rods of cruciform section boron steel which move vertically in the channels between the fuel elements. These rods do not penetrate the pressure vessel and are operated externally by a magnetic mechanism, thereby dispensing with the need for high pressure glands. The primary system in which the pressure is regulated by the pressuriser is fitted with three relief valves which operate should an excessively high pressure develop. The valves discharge into a tank partially filled with water, which will act as a condensing sink.

Capital and Production Cost

The capital cost of the complete nuclear power station will vary depending upon its location, the type of cooling system employed and similar special features. A representative price for a station built in this country on ground having reasonable bearing qualities and where a wet cooling tower is employed would be approximately £3,200,000, representing £160 per kW, a most attractive figure for a nuclear station of this small capacity.

Based upon the above-mentioned capital cost and current prices for enriched uranium, the table on the pull-out page gives figures of the production cost at various load factors. These will be seen to confirm the earlier statement that, where oil costs £10 per ton or coal £5 per ton, the station is competitive. It should be emphasised that this station is no physicist's immature brain-child but a well-tried engineering plant in which such confidence is felt that Humphreys and Glasgow in collaboration with their associates, Babcock and Wilcox, would be prepared to give cost and performance guarantees appropriate to the circumstances in which the station is to be built and operated.

ME — 30 MW BWR

By G. Gordon Jackson

Mitchell Engineering

The 30 MW nett electrical power plant offered by Mitchell Engineering is a forced circulation boiling water reactor using a "reboiling" cycle. The reactor is rated at 110 MW thermal output and produces the saturated steam required for the steam turbine to give the gross electrical output of 31·6 MW. The reactor is cooled and moderated by demineralised water, which is circulated through the cooling channels in the

Condenser (Typical)	
Pressure	2 in Hg. abs.
Steam flow	281,000 lb per hour
Duty	266 × 10^6 Btu per hour
Inlet raw water temperature	80° F
Outlet raw water temperature	95° F
Condensate temperature	101° F
Cooling water flow	50,000 gallons per min
Condensate Pumps	
Number	Two (one spare)
Capacity	570 gallons per min
Net developed head	165 ft
Net positive suction head	15 ft
Suction temperature	101° F
Reactor Feedwater Pumps	
Number	Two (one spare)
Capacity	570 gallons per min
Net developed head	2,850 ft
Suction pressure	25 lb per sq. in
Suction temperature	105° F
Secondary Steam Generator	
Duty	64·0 × 10^6 Btu per hour
Tube side (reactor) pressure	1,200 lb per sq. in
Shell side pressure	600 to 1,200 lb per sq. in
Steam flow	69,700 lb per hour at 600 lb per sq. in
Reactor water flow rate	872,000 lb per hour
Reactor water inlet temperature	567° F
Reactor water outlet temperature	508° F
Feedwater temperature	316° F

H&G — 20 MW PWR

General Description of the Reactor	
Main contractor	Humphreys & Glasgow Limited
Reactor	Pressurised water, designed and supplied by Babcock & Wilcox Limited of London
Net electrical output	20 MW
Design life of plant	20 years
Reactor	
Rated thermal power	73 MW
Coolant and moderator	Pressurised light water
Fuel	Uranium oxide
Initial enrichment	2·5 per cent
Form	Rod
Cladding material	Zircalloy-2
Coolant operating pressure, gauge	1,750 lb per sq. in
Coolant mean temperature	520° F (271° C)
Core	
Overall dimensions	Diameter 50 in; height 80 in
Number of fuel elements	21
Fuel rods per element	217
Rod length	60 in
Rod diameter	0·47 in
Total uranium oxide charge	5·75 tonnes
Fuel element average thermal rating	12·7 MW per tonne

Fuel Cycle	*Equilibrium Cycle*	*First Cycle*
Interval between refuelling operations—full power days	520	535
Inner zone:		
Number of elements	9	9
Initial weight of uranium, kg	2,152	2,172
Initial enrichment, per cent	1·87	2·0
Outer zone:		
Number of elements	12	12
Initial weight of uranium, kg	2,896	2,896
Initial enrichment, per cent	2·5	2·5
Average burn-up of rejected fuel, MWD per tonne	13,000	

Primary Circuit	
Number of primary loops	2
Total water flow	8 million lb per hour
Outlet temperature from reactor	532° F (277° C)
Inlet temperature to reactor	508° F (264° C)
Operating pressure, gauge	1,750 lb per sq. in
Primary Circulating Pumps	
Number of pumps	2
Type	Glandless centrifugal
Drive	Constant speed electric
Pressure rise through pumps	62 lb per sq. in
Electrical power consumption	872 kW
Secondary Circuit	
Total steam flow	282,000 lb per hour
Steam pressure	500 lb per sq. in
Steam quality	Dry saturated (465° F)
Turbo-Alternator	
Gross generating capacity	22 MW
Station electrical output	20 MW
Overall thermal efficiency based on output	27·4 per cent

Production Costs			
Approximate capital cost of station	£3,200,000		
Load factor, per cent	40	60	80
Annual electrical output, kWh × 10^8	70	105	140
	d/kWh	d/kWh	d/kWh
Capital charges (20 year life, 5¼ per cent interest)	0·92	0·61	0·46
Fuel cost (equilibrium cycle)	0·44	0·41	0·40
Operating and maintenance cost (£90,000 per annum)	0·31	0·20	0·15
	1·67	1·22	1·01

HS — 20 MW OMR

General Description of the Reactor	
Company	Hawker Siddeley Nuclear Power Company
Identification of reactor	Organic moderated and cooled reactor
Rated thermal power	66·2 MW
Net electrical power	20 MW
Coolant and moderator	Terphenyl + associated polymer
Fuel:	
Type	Uranium oxide
Composition	Pelleted
Enrichment	1·7 per cent uranium 235
Form	Bundles of rods
Cladding material	Stainless steel
Availability	95 per cent
Design life:	
Whole plant	20 years
Stage of Development	
Reactor system:	
Feasibility study	Complete
Economic evaluation	In progress
Reactor experiments	In progress
Proposed reactor:	
Prototype design	In progress
Earliest possible commissioning date of complete power reactor:	
(1) In UK	1964
(2) Abroad	1965
Heaviest single component for overseas delivery	20 tons; reactor pressure vessel
General Description of the Power Cycle	
Method of power generation	Steam turbine
Turbine stop valve pressure	600 lb per sq. in
Turbine stop valve temperature	615° F
Condenser vacuum	28·7 in Hg.
Wetness	11·6 per cent
Water extraction	Between turbine cylinders
Heat rejection	River (or cooling tower)
Cooling water temperature	65° F
Reactor Core	
Nominal height	5 ft
Nominal diameter	5·36 ft
Total weight (without shielding)	25,000 lb
Core materials:	
Mild steel vessel and core support, stainless steel fuel canning, SAP coolant tube, in contact with terphenyl moderator and coolant, which is non-corrosive at reactor operating temperature	
Description of core:	
Number of channels	294
Flow through channels	Upwards
Inlet temperature	295° C
Bulk outlet temperature	341° C
Central channel average rating	15·5 MW per tonne
Reflector	Terphenyl
Maximum heat flux	200,000 Btu per sq. ft per hour
Burnout flux	420,000 Btu per sq. ft per hour
Fuel	
Uranium oxide pellets	0·5 in OD
Cladding	Stainless steel
Number of rods per sub-assembly	19
Sub-assembly coolant tube	SAP
Sub-assembly active length	2·5 ft
Number per channel	2
Heat transfer surface	Plain
Fuel Inventory	8 tonnes of uranium
Average burn-up of the fuel	10,000 MW days per tonne
Initial uranium 235 content	1·7 per cent
Discharge uranium 235 content	0·9 per cent
Plutonium content	0·5 per cent
Moderator and coolant	Terphenyl + associated polymer
Pressure	70 lb per sq. in
Average temperature	318° C
Chief decomposition products	H_2 and polymer
Purification	As for coolant
Make-up	100 lb per hr
Inventory	40 tons

Temperature coefficients of reactivity at operating conditions $\Delta k/°C$	New core	Greatest effective burn-up
Coolant	$-3·8 \times 10^{-5}$	0
Moderator	-17×10^{-5}	0
Fuel	-4×10^{-5}	-4×10^{-5}
Coolant Loss	Large negative Δk	

Reactor Control	
Number of control rods	19
Arrangement	Triangular lattice
Position	Replacing single fuel channels
Control rod material	Boron steel
Control rod drive	Synchronous electric motors
Control rod worth	11·4 per cent total
Operating Characteristics	
Control rod worth	Sufficient to override the small xenon poisoning
Average fuel life	4 years
Fuel element rearrangement	At yearly intervals
Fuel cycle development	Plutonium enrichment of natural uranium possible
Mechanical Components	
Reactor vessel	1 in thick mild steel cylindrical vessel, 8 ft dia. × 27 ft high
Heat exchangers	Tube in shell evaporators and superheater mounted vertically as separate units
Coolant circuit	2 independent circuits of 16 in nom. bore m/s piping
Coolant circulators	2 single stage centrifugal pumps plus one standby, 168 b.h.p. electrical drive
Coolant treatment plant	By-pass circuit incorporating filtration, degassing, and distillation stages
Moderator cooling	Part of reactor coolant is diverted through the moderator space
Fuel handling	Off load, but without reactor dismantling. Storage in cooling pond.
Shielding	Concrete
Containment	1½ in thick steel cylinder 42 ft dia.
Maintenance	Primary shielding on core will be sufficient to permit reasonable access to reactor circuit for maintenance and inspection of heat exchangers and pumps.
Civil Engineering	
Site requirement	Approximately 1 acre. No reactor building required, small reactor control room adjacent to turbine hall.
Turbine hall dimensions	55 ft by 80 ft
Turbine hall crane, capacity	50 tons
Turbine hall crane, span	50 ft
Economic Analysis	
Capital cost of plant in home country	£2,200,000
Capital cost of first fuel load	£1,100,000
Capital charges, based on 5½ per cent interest, and 70 per cent utilisation	0·41*d* per kWh
Fuel cycle cost including terphenyl make-up	0·45*d* per kWh
Net generating cost less insurance, labour and maintenance	0·86*d* per kWh
Annual estimated generation of electrical energy at 70 per cent load factor	120 × 10^6 kWh

GEC — 30 MW GCR

General Description of the Reactor	
Company	The General Electric Company Ltd. of England
Identification of reactor	GEC–Simon-Carves gas-cooled graphite moderated reactor
Rated thermal power	100 MW
Net electrical power	30 MW
Coolant	Carbon dioxide
Moderator	Graphite, grade A
Fuel:	
Type	Uranium dioxide
Composition	Pellets
Enrichment	2·16 per cent uranium 235
Cladding material	Stainless steel
Stage of development:	
Feasibility study	Complete
Economic evaluation	Complete
Reactor experiments	Complete
Prototype design	In progress

General Description of the Power Cycle		
After SRU stop valve:		
Pressure	900 lb per sq. in	63 atu
Temperature	900° F	480° C
Steam flow per SRU	151,600 lb per hr	68,675 kg per hr
Feed temperature at economiser inlet	320° F	160° C
Circulator turbine:		
Exhaust pressure	200 lb per sq. in	14 atu
Exhaust temperature	622° F	328° C
Steam flow per turbine	61,000 lb per hr	27,700 kg per hr
Main turbine:		
Exhaust pressure	1·2 in Hg	30·5 mm Hg
Exhaust wetness	10 per cent	
Main condenser:		
Steam flow	241,100 lb per hr	109,100 kg per hr
Surface area	26,600 sq. ft	2,470 sq. m
Cooling water flow	25,150 g.p.m.	114,000 litres per min.

Reactor Core		
Nominal core diameter	11 ft 6 in	3,520 mm
Core length	11 ft 0 in	3,353 mm
Reflector thickness	2 ft 0 in	610 mm
Weight of graphite	102 tons	104 tonnes
Fuel channel diameter	6 in	152·4 mm
Channel pitch, triangular	12 in	304·8 mm
Number of fuel channels	121	
Fuel and Canning		
Total weight of uranium dioxide	5,941 kg	
Can material	Stainless steel	
Can wall thickness	0·010 in, 0·25 mm	
Maximum design surface temperature	1,280° F	693° C
Number of fuel elements per reactor	484	
Temperature coefficient of reactivity at equilibrium condition:		
Fuel	$-2·7 \times 10^{-5}$ per °C	
Moderator	$+6·0 \times 10^{-5}$ per °C	
Control and Shut-Down Rods		
Number of control rods (motor driven)	27	
Reactivity invested	18 per cent	
Number of flattening rods (motor driven)	7	
Reactivity invested	4 per cent	
Insertion and withdrawal speed (normal)	4 in per min	102 mm per min
Insertion speed (fast)	10·5 in per sec	267 mm per sec
Number of additional shut down rods (pneumatic drive)	23	
Reactivity invested	4 per cent	
Insertion speed	Less than 1 second	
Absorber material	3 per cent boron stainless steel	
Mechanical Components		
Pressure vessel:		
Material	Silicon killed carbon manganese steel	
Outside diameter	18 ft 2 in	5,537 mm
Overall length	35 ft 7 in	10,850 mm
Thickness	3·44 in	87 mm
Maximum working pressure	400 lb per sq. in	28·2 atu
Maximum working temperature	500° F	260° C
Steam raising units:		
Number	2	
Overall length of pressure shell	40 ft 0 in	12,190 mm
Internal diameter of pressure shell	10 ft 0 in	3,048 mm
Thickness of cylinder	1·88 in	47·6 mm
Heating surfaces:		
Superheater	5,560 sq.ft	516 sq.m
Evaporator	15,275 sq.ft	1,419 sq.m
Economiser	13,100 sq.ft	1,217 sq.m
Shielding Materials	2 per cent boron steel, steel, concrete and Hydrobord	
Coolant Circuit		
Maximum working pressure	400 lb per sq. in.	28·2 atu
Total mass flow through reactor	703 lb per sec.	318·8 kg per sec

Reactor gas inlet temperature	500° F	260° C
Reactor gas outlet temperature	1,000° F	538° C
Circuit pressure drop	40 lb per sq. in	2·8 kg per cm²
Gas Circulators		
Type	Single stage, centrifugal (2)	
Drive	Geared back pressure steam turbine	
Circulator power (total at turbine shafts)	4 MW	
Containment Vessel		
Diameter of cylinder	60 ft 0 in	18,290 mm
Overall height	38 ft 9 in	15,240 mm
Thickness of cylinder	0·63 in	15·9 mm
Design pressure	55 lb per sq in	3·87 kg/cm²
Economics		
Estimated cost (British civil costs, level site, US fuel prices)	£5,460,000 (£182 per kW)	
Annual fuel hire charge	4 per cent	
Amortisation rate including insurance	14 per cent	
Annual operating time	6,000 hours	
Average burn-up	10,000 MWD per tonne	
Production Costs		
Annual charges on capital cost	1·02 pence per kWh	
Annual fuel-hire charge	0·03 " "	
Annual charges on fabrication of first fuel charge	0·01 " "	
Coolant annual charge on first filling and cost of make-up	Negligible	
Operating costs—staff (50 men) and maintenance	0·22 pence per kWh	
Annual fuel-replacement cost	0·11 " "	
Total cost	1·39 pence per kWh	

EE — 11 MW OMR

General Description of the Reactor	
Company	English Electric
Rated thermal power	45·5 MW
Net electrical power	11·4 MW
Coolant and moderator	Terphenyl (Santowax R)
Fuel	
Type	Metal alloy
Composition	Uranium, molybdenum, aluminium
Enrichment	2·0 per cent atomic weight
Form	Concentric double cylinder
Cladding material	Finned aluminium
Availability	90 per cent estimated
Design life	
Whole plant, reactor core, generating equipment	20 years approx.
Stage of Development	
Proposed reactor prototype construction	Piqua, Ohio, completed end of 1961
Earliest possible commissioning date of complete power reactor at a site in UK	30 months
Heaviest single component for overseas delivery—	
Steam raising unit	40 tons approx.
Generator transformer	60 tons approx.
General Description of the Power Cycle	
Method of power generation	Steam turbine
Description of plant	
Steam pressure at TSV	450 lb per sq. in
Steam temperature at TSV	550° F
Final feed temperature	337° F
Turbine maximum continuous rating	12·5 MW
Deviation from normal power generation practice	None
Reactor Core	
Overall dimensions and weight	Core tank, 26·7 ft long, 6·3 ft ID, 35 tons approx.
Core materials	Terphenyls, uranium alloy, aluminium, stainless steel, nickel

Description of core—85 vertical channels, downward flow of coolant, inlet temperature 523° F and outlet temperature 575° F, heat transfer coefficient 1,180 Btu per hr per sq. ft° F maximum heat flux in core 172,000 Btu per hr per sq. ft, fuel elements and control rods supported and guided by upper and lower steel grid plates which are carried from annular thermal shield.

Description of fuel.—Fissile material uranium 235, aluminium cladding, 0·5 mil thickness nickel bonding between fuel and cladding, fuel subassemblies consisting of two concentric tubes positioned between inner and outer stainless steel tubes, supported in channels by steel grid plates, heat transfer surfaces consisting of helical finning opposed on opposite surfaces.

Fuel inventory.—118 kg uranium 235.

Initial enrichment—2·0 per cent atomic weight.

Description of moderator and reflector.—Commercially available mixture of terphenyls—Santowax R. The terphenyls are aromatic hydrocarbon compounds which are derivatives of benzene and consist of three benzene rings linked together by covalent bonds. They exhibit high thermal and radiation stability, have low vapour pressure at reactor operating temperatures and are non-corrosive. Under operating conditions the moderator-coolant undergoes radiation damage with the formation of various decomposition gases and higher molecular weight organic compounds. The decomposition gases, consisting primarily of hydrogen, methane and similar materials, are removed in a coolant degasification system by a flashing and venting process. The high molecular weight compounds consist primarily of long chained polymers and are removed by vacuum distillation in a coolant purification system.

Reactivity.—Negative overall temperature coefficient $5·7 \times 10^{-4}$ per ° F.

Description of reactor control.—7 control rods, cylindrical configuration control rod material boron 10 in boron carbide, control rod drive by magnetic jack, with maximum withdrawal rate 0·175 in per second, control rod worth 10 per cent.

Operating characteristics.—Preheating of the organic liquid is required prior to start-up. Steam is dumped through the main condenser during reactor start-up. Turbine control is carried out manually. Reactor control is based on constant core flow and constant outlet temperature. Reactor inlet temperature is regulated by organic bypass of the heat exchanger. Start-up time from cold to full load is 4 to 5 hours. Restart from scram to full load is only 45 minutes. Reactor portion of the plant can meet continuous ramp load increases and decreases of 20 per cent per minute of rated electrical load over the range 20-100 per cent and can meet instantaneous load changes of +20, −100 per cent over the same range.

Mechanical Components	
Reactor vessel	Cylindrical, carbon steel wall thickness 2 in, design pressure 300 lb per sq. in
Heat exchanger	Two only, standard shell and tube boiler and superheater of carbon steel, design pressure 300 lb per sq. in organic, 500 lb per sq. in steam
Coolant circuit	One loop consisting of carbon steel piping and valves
Coolant circulators	Two standard chemical pumps of carbon steel, 6,000 g.p.m. against 190 ft head
Coolant treatment plant	Degasification carried out under vacuum. Coolant pressurised by pumps with nitrogen blanket. High polymers removed by vacuum distillation.
Fuel handling and storage	Fuelling operations carried out during reactor shut-down. Top shield removed from reactor and replaced by fuel handling cask suitably shielded for transporting irradiated fuel to storage pool. Fuel handling cask also handles and loads new fuel
Shielding	Terphenyl, steel thermal shield and concrete biological shield. Radiation in accessible areas limited to 0·75 mr per hr. Radiation level in heat transfer system area about 100 mr per hr
Maintenance	Limited access is available to primary loop components during full power operation.
Containment	Containment is not necessary owing to low system pressure. Containment shell is being provided at Piqua only because of close proximity of a highly residential area
Civil Engineering	
Site requirements	About 5 acres (excluding construction area)
Size and construction of reactor building	150 ft × 75 ft × 25 ft high
Reactor building crane	30 tons capacity, 70 ft span
Turbine hall dimensions	95 ft × 60 ft × 20 ft high
Turbine hall crane	20 tons capacity, 40 ft span

DH — 16 MW HTGCR

General Description of the Reactor	
Company	The De Havilland Engine Co. Ltd.
Identification of reactor	Y.113 Land Based
Rated thermal power	75 MW
Net electrical power	16 MW
Coolant	Helium
Moderator	Graphite
Fuel:	
Type	Uranium carbide, Thorium carbide
Composition	Dilute dispersion in moderator
Form	Cylindrical pellets
Cladding material	Impermeable graphite
Availability	98 per cent
Design life:	
Whole plant	20 years
Reactor core	About 3 years with 70 per cent load factor
Generating equipment	Steam turbines
Stage of Development	
Reactor system:	
Feasibility study	Complete
Economic evaluation	In progress
Reactor experiments	In progress
Proposed reactor:	
Prototype design	In progress
Earliest possible commissioning date of complete power reactor: (1) UK, about 5 years. (2) Abroad, about 8 years	
Heaviest single component for overseas delivery	60 tons, Reactor Vessel
General Description of the Power Cycle	
Method of power generation	Steam turbine
Steam pressure and temperature	600 lb per sq. in, 850° F
Cycle efficiency	25 per cent
Reactor Core	
Length	72 in
Width (across hexagonal flats)	66·8 in
Weight	8 ton approximately
Core materials	Graphite, uranium carbide and thorium carbide
Direction of channels	Vertical
Number of channels	3,458

Temperatures, °C:	*Inlet*	*Outlet*
Gas	200	700
Passage wall	427	927
Inner graphite surface	487	987
Fuel surface	1,196	1,344
Fuel centre	1,352	1,500

Degree of flux flattening	Assumed flat
Method of flux flattening	Undermoderation
Reflector	Graphite
Heat flux in core (average)	80,500 CHU's per sq. ft per hr
Description of fuel:	Bonded mixture of carbon, thorium carbide and uranium carbide
Fissile material	Uranium 235
Cladding	Graphite
Support of fuel elements	Embedded in moderator
Heat transfer	By radiation to surrounding moderator
Fuel inventory:	
Uranium 235	67 kg
Thorium 232	675 kg
Average burn-up	77 per cent of original uranium 235 8·6 per cent of original thorium 232
Description of reflector	Graphite, radial thickness 2·5 ft, axial thickness 2·0 ft
Reactivity:	
Initial excess reactivity	8 per cent
At end of core life	0·5 per cent

Description of reactor control:
24 Boron carbide absorber rods around periphery of core driven by electric motors through gearing and screw rods. Emergency shut-down by means of boron steel shot injected into core.

B&W — 60 MW PWR

General Description of the Reactor	
Company	Babcock and Wilcox Ltd.
Reactor	Pressurised water
Rated thermal power	210 MW
Net electrical power	60 MW
Coolant and moderator	Light water
Fuel—Type	Uranium dioxide
Composition	Pelleted
Enrichment	2·4 per cent
Form	Rod
Cladding material	Zirconium
Availability (governed by conventional requirements of periodical overhaul and inspection)	92 per cent
Design life, whole plant	20 years
Stage of Development	
Reactor system	
Feasibility study	Complete
Economic evaluation	Complete
Reactor experiments	Complete
Operating experience	Extensive, both land and sea
Possible commissioning date	(1) UK, 36 months (2) Abroad, 42 months
Heaviest single component	150 tons; reactor pressure vessel excluding closure
General Description of the Power Cycle	
Method of power generation	Steam turboalternator
Steam pressure and temperature at turbine	650 lb per sq. in saturated
Exhaust vacuum	28 in Hg
Feed temperature	350° F
No. of feed stages	4
Steam flow	810,000 lb per hr
Heat rejection	Cooling tower
Quantity of cooling water	4,000,000 gal per hr
Cooling water inlet temperature	80° F
Cooling water outlet temperature	92° F
Cooling tower make-up	40,000 gal per hr
Reactor Core	
Diameter	6 ft
Height	6 ft 6 in
Weight	30 tons
No. of fuel elements	52
Fuel rods per element	252
Rod length	6 ft 6 in
Rod diameter	0·400 in
Total uranium oxide charge	15·1 tonnes
Core average thermal rating	14 MW per tonne
Diameter of reactor pressure vessel	9 ft internal
Thickness of reactor pressure vessel	7½ in
Design pressure	2,500 lb per sq. in
Working pressure	2,000 lb per sq. in
Coolant inlet temperature	535° F
" outlet "	565° F
" flow	19×10^6 lb per hr

	First cycle	*Equilibrium cycle*
Interval between refuelling operation—full power days	525	510
Inner zone:		
No. of elements	24	24
Initial weight of uranium—kg	6,150	6,070
Initial enrichment—per cent	1·8	1·73
Outer zone:		
No. of elements	28	28
Initial weight of uranium—kg	7,150	7,150
Initial enrichment—per cent	2·4	2·4
Average burn-up of rejected fuel—MWD per tonne uranium	—	15,000

Mechanical Components	
Reactor vessel	Cylindrical, stainless steel lined
" " closure	Flanged, bolted and seal-welded
Control rods, Number	21
Drive	Electromagnetic
Material	Boron steel
Heat exchangers, Number	4
Type	Shell-and-tube
Arrangement	Vertical
Steam drying	Cyclones
Coolant circulators, Type	Glandless, submersible
Drive	Electric
Coolant treatment plant	Demineralizer, gas stripping, hydrogen overpressure
Fuel handling and storage	Overhead crane, cooling ponds
Shielding, Around reactor	Water tank
Around containment	Concrete wall
Containment	60 ft dia. steel sphere
Civil Engineering	
Site requirement, load bearing	Normal
Reactor house crane, lift	75 tons

Economic Analysis			
Capital cost of plant in home country	£7,200,000		
Load factor—per cent	40	60	80
Annual electrical output—kWh × 10^9	210	315	420
	d/kWh	*d/kWh*	*d/kWh*
Capital charges (20 year life; 5½ per cent interest)	0·69	0·46	0·34
Fuel cost (equilibrium cycle)	0·37	0·35	0·34
Operation and maintenance	0·22	0·15	0·11
	1·28	0·96	0·79

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ENGINEERING'S Chart of British Reactor Groups

Alex. Findlay and Company Ltd.

P.O. Box 2, Motherwell, Lanarkshire.

Member of the Nuclear Power Plant Company.

Structural steel work and general fabrication.

A. Reyrolle and Company Ltd.

Hebburn, Co. Durham.

Member of the Nuclear Power Plant Company.

Design and fabrication of reactor control-rod heads and associated low-frequency generators, fission-product detection equipment, auxiliary power supply, instrumentation and control gear, station auxiliary supply switchgear, high voltage switchgear.

Associated Electrical Industries Ltd.

33 Grosvenor Place, London, SW1.

Member of The Nuclear Power Group (TNPG) and AEI-John Thompson Nuclear Energy Company. Associated with the General Electric Company of America for marine reactor projects.

Electrical engineering of all kinds, nuclear and thermonuclear research, owner of prototype MERLIN reactor.

AEI-John Thompson Nuclear Energy Company Ltd.

Radbroke Hall, Knutsford, Cheshire.

Consortium comprising Associated Electrical Industries and John Thompson, and associated with Balfour Beatty, John Laing and Son, and Morgan Crucible Co. Formed The Nuclear Power Group with the Nuclear Power Plant Company for future tenders.

Design and construction of the 275 MW(e) Berkeley power station for the CEGB, the 5 MW(t) research reactor MERLIN for AEI and the Julich research centre, Germany, and HERALD for AWRE, Aldermaston. Submitted boiling-water ship reactor study to the Galbraith Committee based on General Electric (of America) design.

Atomic Power Constructions Ltd.

28 Theobald's Road, London, WC1. PO Box 90.

Consortium comprising Crompton Parkinson, Fairey Company, International Combustion (Holdings), Richardsons Westgarth and Company, and Nuclear Civil Constructors; and associated with Babcock and Wilcox Ltd.

Design and construction of complete nuclear power stations. Currently constructing the 500 MW(e) Trawsfynydd station for the CEGB.

Babcock and Wilcox Ltd.

Babcock House 209 Euston Road, London, NW1.

Members of the English Electric—Babcock and Wilcox—Taylor Woodrow Atomic Power Group. Associated with the Babcock and Wilcox Company of America and other members of the Babcock and Wilcox organisation. Collaborates with Atomic Power Constructions Ltd., on the construction of their reactor pressure vessels and lifting equipment. Collaborate with Cammell Laird and Company on marine propulsion; and Humphreys and Glasgow Ltd., on pressurised-water reactor stations up to 30 MW(e) output.

Design and construction of steam raising plant at Calder Hall, Chapelcross and Hinkley Point; pressure vessels and lifting equipment at Hinckley Point and Trawsfynydd, containment vessel for the Advanced Gas-cooled Reactor of the UKAEA, and spent fuel handling equipment for Chapelcross and Hinkley Point. Design and construction of reactors of the gas-cooled type and in association with the Babcock and Wilcox Company of America, pressurised water reactors for land and marine use, and swimming pool research reactors.

Balfour Beatty and Company Ltd.

66 Queen Street, London, EC4.

Associated with AEI—John Thompson Nuclear Energy Company Ltd.

Civil engineering contractors for the construction of the 275 MW(e) Berkeley station, responsible for river intake works, turbine hall, pump house and administration building.

Cammell Laird and Company (Shipbuilders and Engineers) Ltd.

Birkenhead, Cheshire.

Shipbuilders and engineers; collaborate with Babcock and Wilcox Ltd. for nuclear marine propulsion projects.

Naval architects, shipbuilders. Liaison work with Babcock and Wilcox Ltd. towards joint production of design studies and tender specifications.

Clarke, Chapman and Company Ltd.

Gateshead 8, County Durham.

Member of the Nuclear Power Plant Company.

Design and fabrication of steam generating plant in association with Head Wrightson and Company Ltd.; also erection equipment including Goliath and other cranes.

Crompton Parkinson Ltd.

Crompton House, Aldwych, London, WC2.

Member of Atomic Power Constructions Ltd.

Supplies switchgear, transformers, electrical auxiliaries, and lighting equipment for the 500 MW(e) Trawsfynydd power station.

De Havilland Engine Company Ltd.

Watford, Herts.

Associated with the Joy Manufacturing Company of Buffalo, New York.

Undertake design studies of small power reactors for marine propulsion and power generation, in particular the high-temperature gas-cooled reactor; design and fabricate experimental equipment including loops for reactor experiments; design and fabricate gas circulators and heat exchange equipment for the zero-energy advanced gas-cooled reactor HERO; make small valves for radioactive circuits, small gas circulators with gas bearings; also produce fuel-element containers.

English Electric Company Ltd.

Queens House, Kingsway, London, WC2.

Member of the English Electric—Babcock and Wilcox—Taylor Woodrow Atomic Power Group. Associated with Atomics International Division of North American Aviation for the application of organic moderated reactors, and Vickers-Armstrongs (Engineers) and (Shipbuilders) for nuclear ship propulsion.

Supplies turbo-alternators and associated equipment for the Hinkley Point station and the AGR; design and manufacture of organic moderated reactors in collaboration with Atomics International, marine applications in collaboration with Vickers-Armstrongs (Engineers) and (Shipbuilders). Design and development of gas-cooled graphite-moderated, organic-moderated and advanced gas-cooled reactor systems.

English Electric—Babcock and Wilcox—Taylor Woodrow Atomic Power Group

Marconi House, London, WC2.

Consortium comprising English Electric Company, Babcock and Wilcox Ltd., and Taylor Woodrow Construction Ltd.

Set up to design and build land-based power stations based on gas-cooled graphite-moderated reactors anywhere in the world. Design and construction of complete nuclear power stations. Currently building the 500 MW(e) Hinkley Point station for the CEGB.

Fairey Company Ltd.

24 Bruton Street, London, W1.

Member of Atomic Power Constructions Ltd. Atomic energy activities are handled by the fully owned subsidiary Fairey Engineering Ltd., Heston, Middlesex.

Design and fabrication of reactor equipment, including charge machines, control-rod mechanisms, graphite structure, irradiated fuel handling equipment. Supply similar equipment for the Trawsfynydd power station.

Fairfield Shipbuilding and Engineering Company Ltd.

Govan, Clydeside.

Member of the Mitchell—Fairfield—Combustion Engineering consortium.

Naval architects, shipbuilders and makers of conventional steam generating equipment and propulsion plants.

Foster Wheeler Ltd.

Foster Wheeler House, 3 Ixworth Place, London, SW3.

Member of Vickers Nuclear Engineering Ltd. associated with Rolls-Royce and Associates Ltd.

Design and fabrication of complete reactor coolant circuitry, including pressure vessels, steam generators and heat exchange equipment.

The General Electric Company Ltd. of England

Erith, Kent.

Member of GEC—Simon-Carves Atomic Energy Group, associated with Maschinenfabrik Augsburg-Nürnberg (MAN) for a ten year period, and with Fuji Electric Manufacturing Company Ltd., the leading company of the First Atomic Power Industry Group (FAPIG).

Design of reactors and fuel elements; design and fabrication of reactor components, fuel handling equipment and power manipulators, turbogenerators and blowers, switchgear, safety equipment, control equipment and panels, and BCD and temperature logging equipment; detail design and construction of zero energy HTGCR ZENITH.

GEC—Simon-Carves Atomic Energy Group

Erith, Kent.

Consortium comprising the General Electric Co. Ltd., and Simon-Carves Ltd., and associated with Motherwell Bridge and Engineering Co. Ltd., and John Mowlem and Co. Ltd. for reactor construction in the United Kingdom. For associations, see General Electric Company Ltd.

Design and construction of gas-cooled graphite-moderated reactors in capacities from 150 to 300 MW(e); advanced gas-cooled reactors (20 MW upwards) for small land-based plants and marine propulsion, and the CONSORT research and training reactor. Currently constructing the 320 MW (e) Hunterston station for the SSEB, and the 150 MW(e) Tokai-Mura station (designed to withstand earthquakes) for the Japan Atomic Power Company.

Hawker Siddeley John Brown Nuclear Construction Ltd.

Richmond Rd. Kingston upon Thames, Surrey.

Consortium of Hawker Siddeley Nuclear Power Company Ltd. and John Brown and Company (Clydebank) Ltd. set up to co-operate on nuclear ship projects.

Hawker Siddeley Nuclear Power Company Ltd.

Sutton Lane, Langley, Nr. Slough, Bucks.

Associated with Hawker Siddeley John Brown Nuclear Constructions Ltd.

Designers of organic-moderated reactor for ship propulsion, power production and heat generation. Designers and builders of JASON research and training reactor, of which modifications have been sold to the UKAEA and Reactor Centrum Nederland. Operate prototype JASON, produce impermeable graphite for high-temperature reactor fuel cans and channel sleeves, design and build in-pile and out-of-pile testing loops. Make high-current switches for fusion experiments, glove boxes and glove-box hoists.

Head, Wrightson Processes Ltd.

"The Friarage," Yarm, Yorkshire.

Member of the Nuclear Power Plant Company, and The Nuclear Power Group

Design, development and contracting organisation; responsible for heat exchangers, graphite structure, shield cooling system, carbon-dioxide storage plant, blowdown and evacuating system, pile cap piping, pond water cooling and treatment systems, and effluent treatment system. Independently supplies material testing reactors of the DIDO type, of which six have been sold (purchasers include Australia, Germany and Denmark); have also supplied flasks, incinerators and other equipment associated with DIDO type reactors.

Humphreys and Glasgow Ltd.

22 Carlisle Place, London, SW1.

Consulting engineers, formerly associated with Alco Products Incorporated of New York. Since November, 1959, associated with Babcock and Wilcox Ltd., London. Co-owners of Nuclear Chemical Plant Ltd.

Design and application of power stations up to 30 MW(e) capacity based on the Babcock and Wilcox pressurised-water reactor.

International Combustion Nuclear Applications Ltd.

19 Woburn Place, London, WC1.

Member of International Combustion Group and Atomic Power Constructions Ltd.

Design, fabrication and erection of pressure vessels, heat exchangers, gas ducting, expansion joints, pipework for steam and water systems, standpipes and charge tubes for reactors, flasks, winches and storage systems for irradiated fuel elements and control rods, test rigs, and in-pile and out-of-pile loops.

John Brown and Company (Clydebank) Ltd.

Clydebank, Dumbartonshire.

Associated with Hawker Siddeley Nuclear Power Company Ltd. for nuclear ship projects

John Laing and Son Ltd.

Page Street, Mill Hill, London, NW7.

Currently associated with AEI—John Thompson Nuclear Energy Company but not restricted in contracting for other companies.

Civil engineering contractors for 275 MW (e) Berkeley station.

And Their Associated Companies at Home and Abroad

John Mowlem and Company Ltd.

91 Ebury Bridge Road, London, SW1. — Civil engineering contractor for 320 MW (e) Hunterston power station.

Associated with GEC—Simon-Carves Atomic Energy Group.

John Thompson Ltd.

Wolverhampton. — Design and fabrication of reactor pressure vessels, thermal shields, heat exchangers, and associated equipment, and fabricators of the gas-circuit bellows units for the 275 MW(e) Berkeley station. Fabrication of the stainless-steel reactor vessel and heat exchanger system for the Dounreay fast-breeder reactor.

Member of the AEI—John Thompson Nuclear Energy Company Ltd. Co-owner of Nuclear Chemical Plant Ltd.

Kennedy and Donkin

12 Caxton Street, London, SW1. — Consultants; nuclear work has included Hunterston and SENN, Italy, nuclear power stations, and specification and report on international competitive tenders for large nuclear power station for Swedish State Power Board.

Miles Hivolt Ltd.

13-15 Mortimer Road, Hove 3, Sussex. — Particle accelerators, subcritical assemblies, and pulsed subcritical assemblies.

United Kingdom and Commonwealth agents for Societe Anonyme des Machines Electrostatiques (SAMES) of Grenoble.

Mitchell Engineering Ltd.

1 Bedford Square, London, WC1. — Main contractors for design and erection of land-based power stations of 15 to 160 MW using boiling-water reactors, also marine propulsion units from 20,000 to 50,000 s.h.p. Design and fabrication of steam-raising equipment, power-station components and heavy engineering. Mitchell Construction were the principal contractors for the Chapelcross power station. Prepared designs for nuclear cargo submarine Moby Dick.

Member of the Mitchell—Fairfield—Combustion Engineering consortium, and associated with Mitchell Construction Company, and AMF Atomics Inc. In 1958 associated with Brown Boveri in bidding for German power station contracts.

Mitchell—Fairfield—Combustion Engineering Nuclear Power Consortium

1 Bedford Square, London, WC1. — The consortium was formed specifically for the design and construction of nuclear propulsion systems.

Consortium comprising Mitchell Engineering Ltd., the Fairfield Shipbuilding and Engineering Company Ltd. and Combustion Engineering Inc. (USA), formed in January, 1959.

Morgan Crucible Company Ltd.

52 Battersea Church Road, London, SW11. — Manufacture of reactor grade and impermeable graphite.

Associated with AEI—John Thompson Nuclear Energy Company and with Nuclear Graphite Ltd.

Motherwell Bridge and Engineering Company Ltd.

P.O. Box 4, Motherwell, Scotland. — Supply and erection of reactors, gas ducts and pressure vessels for the steam raising units of the 320 MW(e) Hunterston power station.

Associated with GEC—Simon-Carves Atomic Energy Group.

Nuclear Chemical Plant Ltd.

105 The Broadway, West Ealing, London, W13. — Contractors and consultants to nuclear industry particularly concerned with nuclear fuel processing, reprocessing and waste disposal.

A company formed and owned jointly by Humphreys and Glasgow Ltd., Power-Gas Corporation Ltd., and John Thompson Ltd.

Nuclear Civil Constructors

52-55 Carnaby Street, London, W1. — Civil engineering and construction for the 500 MW(e) Trawsfynydd power station and other nuclear projects.

Civil engineering consortium comprising Trollope & Colls Ltd., and Holland & Hannen and Cubitts Ltd., associated with Atomic Power Constructions Limited.

Nuclear Graphite Ltd.

Sopers Lane, Poole, Dorset. — Manufacture of nuclear grade graphite for moderators, reflectors and thermal columns in gas-cooled reactors.

Owned jointly by AEI—John Thompson Nuclear Energy Company and Morgan Crucible Company Ltd.

The Nuclear Power Group

Radbroke Hall, Knutsford, Cheshire. — Tenders for domestic and foreign nuclear power station contracts, design and construction of complete nuclear power plant, research reactors and marine propulsion plants.

Partnership of two consortia, the Nuclear Power Plant Company and AEI—John Thompson Nuclear Energy Company on an equal basis.

C. A. Parsons and Company Ltd.

Heaton Works, Newcastle-upon-Tyne. — Design and fabrication of turbo-alternators, transformers, condensers, feed heaters, gas circulators, ductwork, instrumentation.

Member of the Nuclear Power Plant Company.

The Nuclear Power Plant Company Ltd.

Booths Hall, Knutsford, Cheshire. — Design and construction of complete nuclear power stations. Currently building the 300 MW(e) Bradwell station and the 200 MW(e) Latina station. Also research reactors and ship propulsion.

Consortium comprising C. A. Parsons and Company Ltd., A. Reyrolle and Company Ltd., Head, Wrightson and Co. Ltd., Sir Robert McAlpine and Sons Ltd., Whessoe Ltd., Strachan and Henshaw Ltd., Alex. Findlay and Company Ltd., and Clarke Chapman and Company Ltd. Formed The Nuclear Power Group with the AEI—John Thompson Nuclear Energy Company for future tenders.

Richardsons, Westgarth and Company Ltd.

P.O. Box 2, Wallsend, Northumberland. — Design and fabrication of turbo-alternator sets, condenser and feed heating plant, dump condensing plant, coolant circulator, coolant duct elbows and associated equipment for the 500 MW(e) Trawsfynydd power station.

Members of Atomic Power Constructions Ltd. and licensees of Brown Boveri and Co. for turbine manufacture.

Rolls-Royce and Associates Ltd.

Derby. — Created for the purpose of designing and procuring nuclear machinery for Naval and merchant vessel application in particular the submarine prototype reactor at Dounreay, and the submarine Dreadnought.

A Company comprising Rolls-Royce Ltd., Foster Wheeler Ltd. and Vickers Ltd.

Simon-Carves Ltd.

Cheadle Heath, Stockport, Cheshire. — Heat exchange and gas circulation systems, water treatment and radioactive waste disposal plant, and civil engineering. Engaged with GEC on 320 MW station at Hunterston (Scotland) and 150 MW station at Tokai-Mura (Japan).

Member of the GEC—Simon-Carves Atomic Energy Group.

Sir Robert McAlpine and Sons Ltd.

80 Park Lane, London, W1. — Design and erection of civil engineering works in connection with reactor projects.

Member of the Nuclear Power Plant Company.

Strachan and Henshaw Ltd.

Steelhoist Works, St. Philips, Bristol 2. — Design and fabrication of fuel handling machinery, and charge and discharge machines. Contracts include Calder Hall, Chapelcross, Dounreay, Bradwell and Latina.

Member of the Nuclear Power Plant Company.

Taylor Woodrow Construction Ltd.

345 Ruislip Road, Southall, Middlesex. — Main civil engineering contractors for the Calder Hall power station. Civil engineering members of the consortium building the Hinkley Point power station.

Member of the English Electric—Babcock Wilcox—Taylor Woodrow Atomic Power Group.

Vickers Ltd.

Vickers House, Broadway, Westminster London, SW1. — See other Vickers companies below.

See other Vickers companies below.

Vickers-Armstrongs (Aircraft) Ltd.

South Marston Works, Swindon. — Manufacture of TRIGA research and training reactors under licence from General Atomic; manufacture subcritical and zero-energy facilities, reactor simulators, experimental loops and special nuclear equipment. Supplied EUREKA subcritical facility to the UKAEA.

Associated with other members of the Vickers organisaion and General Atomics, division of General Dynamics Corporation.

Vickers-Armstrongs (Engineers) and (Shipbuilders) Ltd.

Barrow-in-Furness. — In cooperation with the English Electric Company Ltd. develop organic-moderated reactor for marine propulsion. Also naval architecture, shipbuilding, design of nuclear vessels; design and fabricate fuel-element decanning machines, fuel-element charge and discharge machines, and fuel-element handling flasks.

Associated with English Electric Ltd. and members of the Vickers organisation.

Vickers Nuclear Engineering Ltd.

Vickers House, Broadway, London, SW1. — Design studies of steam-cooled water-moderated reactors for nuclear propulsion.

Consortium comprising Vickers-Armstrongs (Engineers), Vickers-Armstrongs (Shipbuilders), Rolls-Royce Ltd. and Foster Wheeler Ltd. created for the development of nuclear marine propulsion plants. Associated with other members of the Vickers organisation. Also see Vickers Armstrongs and Rolls-Royce and Associates.

Vickers Research Ltd.

Sunninghill, Ascot, Berks. — Design and fabrication of particle accelerators for medical and industrial use.

Associated with other members of the Vickers organisation.

Whessoe Ltd.

Darlington, Co. Durham. — Design and fabrication of pressure vessels. Contracts include pressure vessels for Calder Hall, Chapelcross, Bradwell, Latina, and the Advanced Gas-cooled Reactor at Windscale. Also containment buildings for experimental reactors at Harwell.

Member of the Nuclear Power Plant Company, and The Nuclear Power Group.

'Engineering' Appointments Section

SENIOR MECHANICAL ENGINEER

A senior mechanical engineer is required by a Company engaged in a continuous process industry. The successful candidate will become a member of a management team connected with the management of a large factory. It is essential that candidates have:

(a) A good degree in Mechanical Engineering.

(b) Some engineering background in heavy engineering.

This vacancy is a particularly attractive one for the right calibre person and the future holds out very good prospects. The age limit is 35. A good commencing salary is offered.

Write stating full details, age, qualifications and experience to Box B 799, Offices of ENGINEERING.

THE HARLAND ENGINEERING COMPANY LIMITED · ALLOA

require several

SENIOR DRAUGHTSMEN

in connection with an expanding development programme in the field of centrifugal pumps, hydraulic turbines and medium/large electrical rotating machinery.

Experience in these products whilst advantageous is less important than thorough knowledge of modern mechanical engineering, stress analysis, materials selection and application, and up to date draughting methods.

The Company offers good salaries and working conditions with contributory pension scheme, extended holidays after twelve months and assistance with house acquisition or purchase.

Replies, giving full particulars of age, qualifications and experience, will be treated in strict confidence and should be sent marked "PERSONAL" to:—

CHIEF DRAUGHTSMAN,
B.E.P. WORKS,
ALLOA, SCOTLAND. G 882

BOILER HOUSE SUPERINTENDENT

B.I.P. CHEMICALS LTD., require at their Oldbury group of factories a Superintendent to take charge of a new and modern boiler house, supplying steam for process and generation. Applicants should be fuel technologists and have been in charge of a modern boiler house of not less than 80,000 lb./hr. capacity and be conversant with up-to-date boiler control and instrumentation. The Company offers good conditions of employment and has a generous Pension and Life Assurance Scheme.—Applications should be made in writing giving full details of qualifications and experience to: –

PERSONNEL MANAGER,
B.I.P. CHEMICALS LTD.,
POPES LANE,
OLDBURY, BIRMINGHAM. B 755

Development Engineer

aged 30/40, required for a substantial and rapidly growing concern in the heavy chemical field located in the North of England.

A good Engineering degree is essential, together with experience in experimental and development work in medium engineering associated with chemical plants. A good knowledge of handling of corrosive liquids and gases and thermodynamics is also required. Those unable to satisfy these requirements need not apply.

The successful candidate will be expected to deal with specific technical problems and will be required to suggest and study new developments and practices.

This is a responsible position for which a commensurate salary will be paid.

A sound non-contributory Life Assurance and Pension Scheme is in operation. Bonus Scheme. Housing assistance to married men. 5-day week.

Applications giving full details, i.e. age, education and experience, should be addressed to Box G. 851, Offices of Engineering.

BRANCH MANAGER

London Area Branch Manager with sales experience required. Area includes most of the South East of England. Small staff and modern premises from which a machine knife and shear blade regrinding service is operated. Applicants between the ages of 25 and 50 with managerial and sales experience in the light engineering and edge tool trades should apply in writing, stating previous experience, age, etc., to:

The Secretary, W. Fearnehough Ltd.,
Garden Street Works,
Sheffield, 1.

Salary: £750 per annum, plus commission of approximately the same figure. Company car supplied.

B 810

SENIOR DRAUGHTSMAN

required

for design of plant and layout for manufacture of investment-moulded steel castings. Should hold H.N.C. and have had experience in connection preferably with this type of process, or in steel foundry or other metallurgical plant, or chemical plant.—Applications, giving appropriate details of experience, should be sent to the

PERSONNEL OFFICER,
FAIREY AVIATION LIMITED,
HAYES, MIDDLESEX. B 738

R.C. DETAILERS

CONSULTING ENGINEERS require R.C. DETAILERS; minimum three years experience. Permanent position. Pension scheme, luncheon vouchers.—Send details of experience and salary required to F. R. BULLEN & PARTNERS, DACRE HOUSE, DEAN FARRAR STREET, WESTMINSTER, S.W.1. B 703

PUBLIC APPOINTMENTS

NUCLEAR POWER PLANT OPERATION

SHIFT MANAGERS are required by The United Kingdom Atomic Energy Authority, Production Group, at Windscale and Calder Works, Sellafield, Seascale, Cumberland.

Applications are invited from Engineers and Physicists to fill vacancies on the Advanced Gas Cooled Reactor project and at the Calder Hall Nuclear Power Station, to be responsible, on shift, for the safe and efficient operation of their station, including nuclear reactors, steam and electrical generating plant and associated experimental facilities.

Engineers must have served a recognised engineering apprenticeship and be Corporate Members of a Senior Engineering Institution or equivalent. Physicists should possess a good Honours Degree. Candidates should have had experience of plant operation, i.e. shift operation in a power station or work on a process plant or large scale research facility. A course of training at a Reactor School and at an operating Nuclear Power Station will be provided.

Salary within the scale £1370-£1825 p.a. according to qualifications and experience with additional payments for regular shift work.

Contributory Superannuation. Staff Housing Scheme.

Send postcard for application form, quoting reference P/W.23/J.2 to RECRUITMENT OFFICER, U.K.A.E.A., PRODUCTION GROUP, WINDSCALE AND CALDER WORKS, SELLAFIELD, SEASCALE, CUMBERLAND.

Closing Date: 25th April, 1960. B 790

HUDDERSFIELD COLLEGE OF TECHNOLOGY

Principal: DR. W. E. SCOTT, M.B.E.

DEPARTMENT OF CIVIL AND MECHANICAL ENGINEERING

Required as soon as possible GRADE "B" ASSISTANT to teach PRODUCTION ENGINEERING SUBJECTS in courses up to Higher National Diploma (Production), including Principles of Engineering Production, and to carry out research relating to Production Engineering.

Salary (Burnham Scale): £700 p.a. by £27 10s. p.a. to £1150 p.a. There are additions for approved qualifications and training and the commencing salary may include increments for approved industrial experience.

Forms of application and further particulars obtainable from the PRINCIPAL, to whom applications should be returned without delay.

H. GRAY,
CLERK TO THE GOVERNORS. B 802

THE UNIVERSITY OF LIVERPOOL

Applications are invited for the following awards:—

A limited number of UNIVERSITY FELLOWSHIPS in the Faculty of Engineering value £450 per annum, tenable for one year in the first instance, but renewable for a second year.

A limited number of Postgraduate Studentships, value £245 per annum, tenable for one year, but renewable for a second or third year.

The holder must pursue a full-time course of training in research within the University.

Applications, which should include particulars of age, academic career and qualifications, together with the names of three referees and quoting reference CV/EN and accompanied by published or manuscript work, should be received not later than 7th May, 1960, by the REGISTRAR, from whom further particulars of the conditions of appointment may be obtained. B 791

THE UNIVERSITY OF MANCHESTER

Applications are invited for the posts of SENIOR LECTURER and LECTURER IN ENGINEERING (MECHANICAL). Preference will be given to candidates with a major interest in Applied Thermodynamics or Applied Mechanics, especially Theory of Machines. Some experience of Mechanical Design would be an advantage. University regulations permit teaching staff to read for the degrees of M.Sc. and Ph.D. The salary scales per annum are as follows: Senior Lecturer, £1700 to £2050; Lecturer, £900 to £1650. Membership of F.S.S.U. and Children's Allowance Scheme. Initial salary according to qualifications and experience. Applications should be sent not later than May 7th, 1960, to the REGISTRAR, THE UNIVERSITY, MANCHESTER, 13, from whom further particulars and forms of application may be obtained. Applications by airmail letter, in the first instance, will be considered from overseas candidates. B 789

THE ROYAL TECHNICAL COLLEGE OF EAST AFRICA, NAIROBI

INCORPORATING THE GANDHI MEMORIAL ACADEMY

Applications are invited for a LABORATORY TECHNICIAN to work in the Heat Engines Laboratories of the Faculty of Engineering, the Royal Technical College of East Africa.

Initially the duties will include work on the installation of steam and Internal Combustion Engine Plant, in addition to normal laboratory duties comprising preparation of apparatus for experiments and maintenance of plant.

Candidates should have had training and subsequent experience as steam or Internal Combustion engine fitters.

Salary Scales: £1005 by £45 to £1455 per annum together with a child allowance for up to 3 dependent children (the point of entry being determined by qualifications and experience). There is a College Medical Scheme and Provident Fund in operation.

Overseas Leave: Every three years with passage provision up to 3 adult passages.

Housing: Housing together with heavy furniture is provided at a nominal rent.

Applications (8 copies) giving age, qualifications, experience and names of 3 referees, should be sent to COUNCIL FOR OVERSEAS COLLEGES, 12, LINCOLN'S INN FIELDS, LONDON, W.C.2, by 30th April, 1960. B 785

ST. STEPHEN'S HOSPITAL, FULHAM ROAD, CHELSEA, S.W.10

(469 BEDS)

ASSISTANT ENGINEER

Applications are invited for the above vacancy. Salary scale £570 to £700 per annum plus London Weighting £30. Practical training in mechanical engineering essential and experience required of engineering maintenance in charge of craftsmen and operatives. Candidates should possess or be studying for one of the recognised technical qualifications in Mechanical Engineering or Electrical Engineering, or hold a second class Marine Engineers certificate. Application forms obtainable from THE GROUP SECRETARY. B 793

BARROW-IN-FURNESS EDUCATION COMMITTEE

CENTRAL COLLEGE OF FURTHER EDUCATION

Required in September, 1960, LECTURER to teach THERMODYNAMICS up to Higher National Diploma level. Salary scale £1370 to £1550.

Application forms, obtainable from W. G. BATE, CHIEF EDUCATION OFFICER, EDUCATION OFFICES, BARROW-IN-FURNESS, should be returned not later than 29th April, 1960.

LAWRENCE ALLEN,
TOWN CLERK.
TOWN HALL,
BARROW-IN-FURNESS. B 792

THE ROYAL TECHNICAL COLLEGE OF EAST AFRICA, NAIROBI

INCORPORATING THE GANDHI MEMORIAL ACADEMY

Applications are invited for the appointment of LECTURER IN ELECTRICAL ENGINEERING, in the Faculty of Engineering at the Royal Technical College of East Africa in Nairobi.

Candidates should possess a degree in Engineering as well as being Corporate Members of the appropriate professional Institution.

Salary Scale: Lecturer, £1320 by £48 to £1800 per annum together with a child allowance for up to 3 dependent children (the point of entry being determined by qualifications and experience). There is a College Medical Scheme in operation.

Overseas Leave: Every three years with passage provision up to 3 adult passages.

Pension: The post is pensionable and arrangements might be made for the continuance of an approved scheme.

Housing: Housing together with heavy furniture is provided at a nominal rent.

Applications (8 copies) giving age, qualifications, experience and names of 3 referees, should be sent to COUNCIL FOR OVERSEAS COLLEGES, 12 LINCOLN'S INN FIELDS, LONDON, W.C.2, by 30th April, 1960. B 787

And Their Associated Companies at Home and Abroad

John Mowlem and Company Ltd.

91 Ebury Bridge Road, London, SW1.

Civil engineering contractor for 320 MW (e) Hunterston power station.

Associated with GEC—Simon-Carves Atomic Energy Group.

John Thompson Ltd.

Wolverhampton.

Design and fabrication of reactor pressure vessels, thermal shields, heat exchangers, and associated equipment, and fabricators of the gas-circuit bellows units for the 275 MW(e) Berkeley station. Fabrication of the stainless-steel reactor vessel and heat exchanger system for the Dounreay fast-breeder reactor.

Member of the AEI—John Thompson Nuclear Energy Company Ltd. Co-owner of Nuclear Chemical Plant Ltd.

Kennedy and Donkin

12 Caxton Street, London, SW1.

Consultants; nuclear work has included Hunterston and SENN, Italy, nuclear power stations, and specification and report on international competitive tenders for large nuclear power station for Swedish State Power Board.

Miles Hivolt Ltd.

13-15 Mortimer Road, Hove 3, Sussex.

Particle accelerators, subcritical assemblies, and pulsed subcritical assemblies.

United Kingdom and Commonwealth agents for Societe Anonyme des Machines Electrostatiques (SAMES) of Grenoble.

Mitchell Engineering Ltd.

1 Bedford Square, London, WC1.

Main contractors for design and erection of land-based power stations of 15 to 160 MW using boiling-water reactors, also marine propulsion units from 20,000 to 50,000 s.h.p. Design and fabrication of steam-raising equipment, power-station components and heavy engineering. Mitchell Construction were the principal contractors for the Chapelcross power station. Prepared designs for nuclear cargo submarine Moby Dick.

Member of the Mitchell—Fairfield—Combustion Engineering consortium, and associated with Mitchell Construction Company, and AMF Atomics Inc. In 1958 associated with Brown Boveri in bidding for German power station contracts.

Mitchell—Fairfield—Combustion Engineering Nuclear Power Consortium

1 Bedford Square, London, WC1.

The consortium was formed specifically for the design and construction of nuclear propulsion systems.

Consortium comprising Mitchell Engineering Ltd., the Fairfield Shipbuilding and Engineering Company Ltd. and Combustion Engineering Inc. (USA), formed in January, 1959.

Morgan Crucible Company Ltd.

82 Battersea Church Road, London, SW11.

Manufacture of reactor grade and impermeable graphite.

Associated with AEI—John Thompson Nuclear Energy Company and with Nuclear Graphite Ltd.

Motherwell Bridge and Engineering Company Ltd.

P.O. Box 4, Motherwell, Scotland.

Supply and erection of reactors, gas ducts and pressure vessels for the steam raising units of the 320 MW(e) Hunterston power station.

Associated with GEC—Simon-Carves Atomic Energy Group.

Nuclear Chemical Plant Ltd.

105 The Broadway, West Ealing, London, W13.

Contractors and consultants to nuclear industry particularly concerned with nuclear fuel processing, reprocessing and waste disposal.

A company formed and owned jointly by Humphreys and Glasgow Ltd., Power-Gas Corporation Ltd., and John Thompson Ltd.

Nuclear Civil Constructors

52-55 Carnaby Street, London, W1.

Civil engineering and construction for the 500 MW(e) Trawsfynydd power station and other nuclear projects.

Civil engineering consortium comprising Trollope & Colls Ltd., and Holland & Hannen and Cubitts Ltd., associated with Atomic Power Constructions Limited.

Nuclear Graphite Ltd.

Sopers Lane, Poole, Dorset.

Manufacture of nuclear grade graphite for moderators, reflectors and thermal columns in gas-cooled reactors.

Owned jointly by AEI—John Thompson Nuclear Energy Company and Morgan Crucible Company Ltd.

The Nuclear Power Group

Radbroke Hall, Knutsford, Cheshire.

Tenders for domestic and foreign nuclear power station contracts, design and construction of complete nuclear power plant, research reactors and marine propulsion plants.

Partnership of two consortia, the Nuclear Power Plant Company and AEI—John Thompson Nuclear Energy Company on an equal basis.

C. A. Parsons and Company Ltd.

Heaton Works, Newcastle-upon-Tyne.

Design and fabrication of turbo-alternators, transformers, condensers, feed heaters, gas circulators, ductwork, instrumentation.

Member of the Nuclear Power Plant Company.

The Nuclear Power Plant Company Ltd.

Booths Hall, Knutsford, Cheshire.

Design and construction of complete nuclear power stations. Currently building the 300 MW(e) Bradwell station and the 200 MW(e) Latina station. Also research reactors and ship propulsion.

Consortium comprising C. A. Parsons and Company Ltd., A. Reyrolle and Company Ltd., Head, Wrightson and Co. Ltd., Sir Robert McAlpine and Sons Ltd., Whessoe Ltd., Strachan and Henshaw Ltd., Alex. Findlay and Company Ltd., and Clarke Chapman and Company Ltd. Formed The Nuclear Power Group with the AEI—John Thompson Nuclear Energy Company for future tenders.

Richardsons, Westgarth and Company Ltd.

P.O. Box 2, Wallsend, Northumberland.

Design and fabrication of turbo-alternator sets, condenser and feed heating plant, dump condensing plant, coolant circulator, coolant duct elbows and associated equipment for the 500 MW(e) Trawsfynydd power station.

Members of Atomic Power Constructions Ltd. and licensees of Brown Boveri and Co. for turbine manufacture.

Rolls-Royce and Associates Ltd.

Derby.

Created for the purpose of designing and procuring nuclear machinery for Naval and merchant vessel application in particular the submarine prototype reactor at Dounreay, and the submarine Dreadnought.

A Company comprising Rolls-Royce Ltd., Foster Wheeler Ltd. and Vickers Ltd.

Simon-Carves Ltd.

Cheadle Heath, Stockport, Cheshire.

Heat exchange and gas circulation systems, water treatment and radioactive waste disposal plant, and civil engineering. Engaged with GEC on 320 MW station at Hunterston (Scotland) and 150 MW station at Tokai-Mura (Japan).

Member of the GEC—Simon-Carves Atomic Energy Group.

Sir Robert McAlpine and Sons Ltd.

80 Park Lane, London, W1.

Design and erection of civil engineering works in connection with reactor projects.

Member of the Nuclear Power Plant Company.

Strachan and Henshaw Ltd.

Steelhoist Works, St. Philips, Bristol 2.

Design and fabrication of fuel handling machinery, and charge and discharge machines. Contracts include Calder Hall, Chapelcross, Dounreay, Bradwell and Latina.

Member of the Nuclear Power Plant Company.

Taylor Woodrow Construction Ltd.

345 Ruislip Road, Southall, Middlesex.

Main civil engineering contractors for the Calder Hall power station. Civil engineering members of the consortium building the Hinkley Point power station.

Member of the English Electric—Babcock Wilcox—Taylor Woodrow Atomic Power Group.

Vickers Ltd.

Vickers House, Broadway, Westminster London, SW1.

See other Vickers companies below.

See other Vickers companies below.

Vickers-Armstrongs (Aircraft) Ltd.

South Marston Works, Swindon.

Manufacture of TRIGA research and training reactors under licence from General Atomic; manufacture subcritical and zero-energy facilities, reactor simulators, experimental loops and special nuclear equipment. Supplied EUREKA subcritical facility to the UKAEA.

Associated with other members of the Vickers organisaion and General Atomics, division of General Dynamics Corporation.

Vickers-Armstrongs (Engineers) and (Shipbuilders) Ltd.

Barrow-in-Furness.

In cooperation with the English Electric Company Ltd. develop organic-moderated reactor for marine propulsion. Also naval architecture, shipbuilding, design of nuclear vessels; design and fabricate fuel-element decanning machines, fuel-element charge and discharge machines, and fuel-element handling flasks.

Associated with English Electric Ltd. and members of the Vickers organisation.

Vickers Nuclear Engineering Ltd.

Vickers House, Broadway, London, SW1.

Design studies of steam-cooled water-moderated reactors for nuclear propulsion.

Consortium comprising Vickers-Armstrongs (Engineers), Vickers-Armstrongs (Shipbuilders), Rolls-Royce Ltd. and Foster Wheeler Ltd. created for the development of nuclear marine propulsion plants. Associated with other members of the Vickers organisation. Also see Vickers Armstrongs and Rolls-Royce and Associates.

Vickers Research Ltd.

Sunninghill, Ascot, Berks.

Design and fabrication of particle accelerators for medical and industrial use.

Associated with other members of the Vickers organisation.

Whessoe Ltd.

Darlington, Co. Durham.

Design and fabrication of pressure vessels. Contracts include pressure vessels for Calder Hall, Chapelcross, Bradwell, Latina, and the Advanced Gas-cooled Reactor at Windscale. Also containment buildings for experimental reactors at Harwell.

Member of the Nuclear Power Plant Company, and The Nuclear Power Group.

'Engineering' Appointments Section

SENIOR MECHANICAL ENGINEER

A senior mechanical engineer is required by a Company engaged in a continuous process industry. The successful candidate will become a member of a management team connected with the management of a large factory. It is essential that candidates have:

(a) A good degree in Mechanical Engineering.

(b) Some engineering background in heavy engineering.

This vacancy is a particularly attractive one for the right calibre person and the future holds out very good prospects. The age limit is 35. A good commencing salary is offered.

Write stating full details, age, qualifications and experience to Box B 799, Offices of ENGINEERING.

THE HARLAND ENGINEERING COMPANY LIMITED · ALLOA

require several

SENIOR DRAUGHTSMEN

in connection with an expanding development programme in the field of centrifugal pumps, hydraulic turbines and medium/large electrical rotating machinery.

Experience in these products whilst advantageous is less important than thorough knowledge of modern mechanical engineering, stress analysis, materials selection and application, and up to date draughting methods.

The Company offers good salaries and working conditions with contributory pension scheme, extended holidays after twelve months and assistance with house acquisition or purchase.

Replies, giving full particulars of age, qualifications and experience, will be treated in strict confidence and should be sent marked "PERSONAL" to—

CHIEF DRAUGHTSMAN,
B.E.P. WORKS,
ALLOA, SCOTLAND. G 882

BOILER HOUSE SUPERINTENDENT

B.I.P. CHEMICALS LTD., require at their Oldbury group of factories a Superintendent to take charge of a new and modern boiler house, supplying steam for process and generation. Applicants should be fuel technologists and have been in charge of a modern boiler house of not less than 80,000 lb./hr. capacity and be conversant with up-to-date boiler control and instrumentation. The Company offers good conditions of employment and has a generous Pension and Life Assurance Scheme.—Applications should be made in writing giving full details of qualifications and experience to:—

PERSONNEL MANAGER,
B.I.P. CHEMICALS LTD.,
POPES LANE,
OLDBURY, BIRMINGHAM. B 755

Development Engineer

aged 30/40, required for a substantial and rapidly growing concern in the heavy chemical field located in the North of England.

A good Engineering degree is essential, together with experience in experimental and development work in medium engineering associated with chemical plants. A good knowledge of handling of corrosive liquids and gases and thermodynamics is also required. Those unable to satisfy these requirements need not apply.

The successful candidate will be expected to deal with specific technical problems and will be required to suggest and study new developments and practices.

This is a responsible position for which a commensurate salary will be paid.

A sound non-contributory Life Assurance and Pension Scheme is in operation. Bonus Scheme. Housing assistance to married men. 5-day week.

Applications giving full details, i.e. age, education and experience, should be addressed to Box G. 851, Offices of Engineering.

BRANCH MANAGER

London Area Branch Manager with sales experience required. Area includes most of the South East of England. Small staff and modern premises from which a machine knife and shear blade regrinding service is operated. Applicants between the ages of 25 and 50 with managerial and sales experience in the light engineering and edge tool trades should apply in writing, stating previous experience, age, etc., to:

The Secretary, W. Fearnehough Ltd.,
Garden Street Works,
Sheffield, 1.

Salary: £750 per annum, plus commission of approximately the same figure. Company car supplied. B 810

SENIOR DRAUGHTSMAN

required

for design of plant and layout for manufacture of investment-moulded steel castings. Should hold H.N.C. and have had experience in connection preferably with this type of process, or in steel foundry or other metallurgical plant, or chemical plant.—Applications, giving appropriate details of experience, should be sent to the

PERSONNEL OFFICER,
FAIREY AVIATION LIMITED,
HAYES, MIDDLESEX. B 738

R.C. DETAILERS

CONSULTING ENGINEERS require R.C. DETAILERS; minimum three years experience. Permanent position. Pension scheme, luncheon vouchers.—Send details of experience and salary required to F. R. BULLEN & PARTNERS, DACRE HOUSE, DEAN FARRAR STREET, WESTMINSTER, S.W.1. B 703

PUBLIC APPOINTMENTS

NUCLEAR POWER PLANT OPERATION

SHIFT MANAGERS are required by The United Kingdom Atomic Energy Authority, Production Group, at Windscale and Calder Works, Sellafield, Seascale, Cumberland.

Applications are invited from Engineers and Physicists to fill vacancies on the Advanced Gas Cooled Reactor project and at the Calder Hall Nuclear Power Station, to be responsible, on shift, for the safe and efficient operation of their station, including nuclear reactors, steam and electrical generating plant and associated experimental facilities.

Engineers must have served a recognised engineering apprenticeship and be Corporate Members of a Senior Engineering Institution or equivalent. Physicists should possess a good Honours Degree. Candidates should have had experience of plant operation, i.e. shift operation in a power station or work on a process plant or large scale research facility. A course of training at a Reactor School and at an operating Nuclear Power Station will be provided.

Salary within the scale £1370-£1825 p.a. according to qualifications and experience with additional payments for regular shift work.

Contributory Superannuation. Staff Housing Scheme.

Send postcard for application form, quoting reference P/W.23/J.2 to RECRUITMENT OFFICER, U.K.A.E.A., PRODUCTION GROUP, WINDSCALE AND CALDER WORKS, SELLAFIELD, SEASCALE, CUMBERLAND.

Closing Date: 25th April, 1960. B 790

HUDDERSFIELD COLLEGE OF TECHNOLOGY

Principal: DR. W. E. SCOTT, M.B.E.

DEPARTMENT OF CIVIL AND MECHANICAL ENGINEERING

Required as soon as possible GRADE "B" ASSISTANT to teach PRODUCTION ENGINEERING SUBJECTS in courses up to Higher National Diploma (Production), including Principles of Engineering Production, and to carry out research relating to Production Engineering.

Salary (Burnham Scale): £700 p.a. by £27 10s. p.a. to £1150 p.a. There are additions for approved qualifications and training and the commencing salary may include increments for approved industrial experience.

Forms of application and further particulars obtainable from the PRINCIPAL, to whom applications should be returned without delay.

H. GRAY,
CLERK TO THE Ggovernors. B 802

THE UNIVERSITY OF LIVERPOOL

Applications are invited for the following awards:—

A limited number of UNIVERSITY FELLOWSHIPS in the Faculty of Engineering value £450 per annum, tenable for one year in the first instance, but renewable for a second year.

A limited number of Postgraduate Studentships, value £245 per annum, tenable for one year, but renewable for a second or third year.

The holder must pursue a full-time course of training in research within the University.

Applications, which should include particulars of age, academic career and qualifications, together with the names of three referees and quoting reference CV/EN and accompanied by published or manuscript work, should be received not later than 7th May, 1960, by the REGISTRAR, from whom further particulars of the conditions of appointment may be obtained. B 791

THE UNIVERSITY OF MANCHESTER

Applications are invited for the posts of SENIOR LECTURER and LECTURER IN ENGINEERING (MECHANICAL). Preference will be given to candidates with a major interest in Applied Thermodynamics or Applied Mechanics, especially Theory of Machines. Some experience of Mechanical Design would be an advantage. University regulations permit teaching staff to read for the degrees of M.Sc. and Ph.D. The salary scales per annum are as follows: Senior Lecturer, £1700 to £2050; Lecturer, £900 to £1650. Membership of F.S.S.U. and Children's Allowance Scheme. Initial salary according to qualifications and experience. Applications should be sent not later than May 7th, 1960, to the REGISTRAR, THE UNIVERSITY, MANCHESTER, 13, from whom further particulars and forms of application may be obtained. Applications by airmail letter, in the first instance, will be considered from overseas candidates. B 789

THE ROYAL TECHNICAL COLLEGE OF EAST AFRICA, NAIROBI

INCORPORATING THE GANDHI MEMORIAL ACADEMY

Applications are invited for a LABORATORY TECHNICIAN to work in the Heat Engines Laboratories of the Faculty of Engineering, the Royal Technical College of East Africa.

Initially the duties will include work on the installation of steam and Internal Combustion Engine Plant, in addition to normal laboratory duties comprising preparation of apparatus for experiments and maintenance of plant.

Candidates should have had training and subsequent experience as steam or Internal Combustion engine fitters.

Salary Scales: £1005 by £45 to £1455 per annum together with a child allowance for up to 3 dependent children (the point of entry being determined by qualifications and experience). There is a College Medical Scheme and Provident Fund in operation.

Overseas Leave: Every three years with passage provision up to 3 adult passages.

Housing: Housing together with heavy furniture is provided at a nominal rent.

Applications (8 copies) giving age, qualifications, experience and names of 3 referees, should be sent to COUNCIL FOR OVERSEAS COLLEGES, 12, LINCOLN'S INN FIELDS, LONDON, W.C.2, by 30th April, 1960. B 785

ST. STEPHEN'S HOSPITAL, FULHAM ROAD, CHELSEA, S.W.10

(465 BEDS)

ASSISTANT ENGINEER

Applications are invited for the above vacancy. Salary scale £570 to £700 per annum plus London Weighting £30. Practical training in mechanical engineering essential and experience required of engineering maintenance in charge of craftsmen and operatives. Candidates should possess or be studying for one of the recognised technical qualifications in Mechanical Engineering or Electrical Engineering, or hold a second class Marine Engineers certificate. Application forms obtainable from THE GROUP SECRETARY. B 793

BARROW-IN-FURNESS EDUCATION COMMITTEE

CENTRAL COLLEGE OF FURTHER EDUCATION

Required in September, 1960, LECTURER to teach THERMODYNAMICS up to Higher National Diploma level. Salary scale £1370 to £1550.

Application forms, obtainable from W. G. BATE, CHIEF EDUCATION OFFICER, EDUCATION OFFICES, BARROW-IN-FURNESS, should be returned not later than 29th April, 1960.

LAWRENCE ALLEN,
TOWN CLERK.
TOWN HALL,
BARROW-IN-FURNESS. B 792

THE ROYAL TECHNICAL COLLEGE OF EAST AFRICA, NAIROBI

INCORPORATING THE GANDHI MEMORIAL ACADEMY

Applications are invited for the appointment of LECTURER IN ELECTRICAL ENGINEERING, in the Faculty of Engineering at the Royal Technical College of East Africa in Nairobi.

Candidates should possess a degree in Engineering as well as being Corporate Members of the appropriate professional Institution.

Salary Scale: Lecturer, £1320 by £48 to £1800 per annum together with a child allowance for up to 3 dependent children (the point of entry being determined by qualifications and experience). There is a College Medical Scheme in operation.

Overseas Leave: Every three years with passage provision up to 3 adult passages.

Pension: The post is pensionable and arrangements might be made for the continuance of an approved scheme.

Housing: Housing together with heavy furniture is provided at a nominal rent.

Applications (8 copies) giving age, qualifications, experience and names of 3 referees, should be sent to COUNCIL FOR OVERSEAS COLLEGES, 12 LINCOLN'S INN FIELDS, LONDON, W.C.2, by 30th April, 1960. B 787

UNIVERSITY OF NOTTINGHAM

Applications are invited from Honours graduates, with industrial and/or research experience, for the following posts:

LECTURER AND ASSISTANT LECTURER IN MECHANICAL ENGINEERING.
LECTURER AND ASSISTANT LECTURER IN CIVIL ENGINEERING.
LECTURER AND ASSISTANT LECTURER IN PRODUCTION ENGINEERING.

Salary scales: Lecturer, £900 to £1650; Assistant Lecturer, £700 to £850, initial salary according to qualifications and experience. Membership of the Universities Superannuation Scheme and children's allowances. Conditions of appointment and form of application, to be returned by 9th May, 1960, from the REGISTRAR. B 783

WESTERN NIGERIA DEVELOPMENT CORPORATION

ASSISTANT MECHANICAL ENGINEER

The Corporation invites applications from suitably qualified candidates for post of Assistant Mechanical Engineer in its Engineering Department.

QUALIFICATIONS: Candidates should possess one of the following qualifications:—

(*a*) A.M.I.Mech.E. or approved equivalent qualification awarded by an Institution outside Great Britain.
(*b*) A recognised Diploma or University Degree in Mechanical Engineering with adequate practical experience in operation and maintenance of Plants and Vehicles.

In addition, candidates must have had at least five years of post-graduate employment, two of which must have been in a responsible position and are expected to have had some experience in the following:—

(*a*) Workshop Management.
(*b*) Office and Stores Organisation.
(*c*) Estimating and Control of Finance.
(*d*) Control of Transport, Plant and Finance.
(*e*) Maintenance, inspection, repair and overhaul of all classes of motor transport, earth moving equipment, Contractors' plant, diesel fuel oil injection equipment, air-conditioning and refrigerating-plant and wood-working machine shops.

DUTIES: The Officer appointed will be posted for duties in one of the Corporation's Maintenance Mechanical Workshops, which may be anywhere in the Western Region of Nigeria.

SALARY SCALE: £1360 : £1420, £1470 by £60 to £1590 per annum plus inducement allowance of £300 per annum for an Overseas officer. Point of entry will depend on qualifications and experience. Prospects for early promotion are excellent.

TERMS OF SERVICE: The terms of service include partly furnished accommodation at the rate of 8½ per cent. of the basic salary; free medical service. (In the case of an expatriate being appointed, an outfit allowance for candidates coming to the tropics for the first time is payable, and a free passage for wife and free passages once each way per tour for children up to 3 in number not over the age of 13 are provided.) Employee is required to contribute 10 per cent. of salary to a Provident Fund; the Corporation contributes an equal amount. Leave at full pay is granted at the rate of 5 days for every completed month of service. Normal length of tour is 18/24 months.

Applications stating age, qualifications and experience with the names of three referees should be forwarded to reach the OFFICIAL SECRETARY (RECRUITMENT BRANCH), OFFICE OF THE COMMISSIONER, WESTERN REGION OF NIGERIA, 178/202, GT. PORTLAND STREET, LONDON, W.1, not later than Saturday, 23rd April, 1960. B 784

THE REPUBLIC OF THE SUDAN

Applications are invited from those suitably qualified to fill a vacancy of SHIFT CHARGE ENGINEER in the Central Electricity and Water Administration, Sudan.

Candidates should have a sound technical training and have had experience in modern steam power stations operating at pressures of 500 lbs./sq. inch with oil fired boilers. A knowledge of diesel engine operation would be an advantage. The selected candidate will be expected to carry out maintenance work on the generating plant if required.

The appointment will be on contract for three years, the first year being probationary.

Salary will be in the range of £S.1100-£S.1670, and the starting point will be fixed according to age, qualifications and experience. In addition to the salary, a cost-of living allowance is payable (£S.187 per annum), and an initial outfit grant of £S.50 on appointment. £S.1 equals £1 0s. 6d. There is no income tax payable in the Sudan.

In addition accommodation will be provided at a rental not exceeding 7½ per cent. of the basic salary. Hard furnishings are available at a nominal rent. Liberal leave on full pay with full passage paid for the Official, Wife and children up to the age of 18 granted after 18 months' service.

Application should be made in writing in the first instance, giving full details of age, qualifications, experience, and with copies of two recent testimonials, to the APPOINTMENTS SECTION, THE SUDAN EMBASSY, CLEVELAND ROW, ST. JAMES'S, LONDON, S.W.1, quoting reference 4/3203.

Closing date: 30th April, 1960. B 788

SECOND OFFICER AND SECOND ENGINEER

Fishery Protection and Research Ships DEPARTMENT OF AGRICULTURE AND FISHERIES FOR SCOTLAND: Pensionable posts, (*a*) one as SECOND OFFICER, (*b*) one as SECOND ENGINEER for men at least 23 on 1.4.60. Qualifications: (*a*) Board of Trade or Ministry of Transport Certificate of Competency as Master (Home Trade); preference for those with Foreign-going or Extra Master's Certificate; (*b*) Board of Trade or Ministry of Transport Certificate of Competency as 1st Class Engineer in Steam or Motor; preference for those with Certificate in both Steam and Motor or Extra 1st Class Certificate. Salary Scales (National rates): (*a*) £745-£865, (*b*) £890-£1055, plus allowances. Promotion prospects. Write ESTABLISHMENT OFFICER, ROOM 364, ST. ANDREW'S HOUSE, EDINBURGH, 1, for application form. Closing date 20th May, 1960. B 809

DRAUGHTSMAN

Applications are invited for the above post, which located in Birmingham.

The work is interesting and varied and is mainly in connection with the design of industrial heating equipment. A knowledge of combustion technique and the use of refractories would, therefore, be an advantage.

Candidates should possess the Ordinary National Certificate in Mechanical Engineering as a minimum qualification.

The salary for the appointment, which is pensionable and subject to medical examination, will be within the range of £733-£853 per annum.

Applications, stating age, qualifications and experience, together with the names of two referees should be addressed to the INDUSTRIAL RELATIONS OFFICER, WEST MIDLANDS GAS BOARD, 6, AUGUSTUS ROAD, EDGBASTON, BIRMINGHAM, 15. G 848

MIDDLESEX COUNTY COUNCIL

EDUCATION COMMITTEE

ENFIELD TECHNICAL COLLEGE

QUEENSWAY, ENFIELD, MIDDLESEX

Required for 1st September, 1960:

DEPARTMENT OF CIVIL AND MECHANICAL ENGINEERING

(1) THREE—LECTURERS IN MECHANICAL ENGINEERING to teach Mechanical Engineering subjects up to Higher National Diploma standard. Candidates must have a University Degree in Engineering and should preferably be Corporate Members of The Institution of Mechanical Engineers. They should have had industrial and teaching or research experience.
(2) ONE—ASSISTANT GRADE B IN MECHANICAL ENGINEERING to teach Mechanical Engineering subjects up to National Certificate standard. Candidates must be University Graduates in Engineering and at least Graduate Members of The Institution of Mechanical Engineers. They should have had industrial or research experience

DEPARTMENT OF ELECTRICAL ENGINEERING

(3) ONE—SENIOR LECTURER IN ELECTRICAL ENGINEERING to teach the subjects of Electrical Theory and Measurements and/or Electrical Power and Machines to Final Degree standard. A knowledge of A.C. Machine Design would be an advantage. Candidates should have a good honours degree and be Corporate Members of The Institution of Electrical Engineers. They should have had good industrial and teaching or research experience.
(4) ONE—LECTURER IN ELECTRICAL ENGINEERING to teach Electronics and Radio Communication to the standard of the Higher National Diploma and I.E.E. Part III Examinations. Candidates should be University Graduates in Electrical Engineering and preferably be Corporate Members of The Institution of Electrical Engineers. They should have had good industrial experience.
(5) TWO—ASSISTANTS GRADE B IN ELECTRICAL ENGINEERING to teach Electrical and Mechanical Engineering subjects in National Certificate and City and Guilds Courses. Candidates should be University Graduates in Electrical Engineering and should have had industrial experience.
(6) ONE—LECTURER IN ELECTRICAL ENGINEERING to teach light current Electrical Engineering subjects to Higher National Diploma standard and Electrical Measurements for the I.E.E. Part III Examination. Candidates should be University Graduates in Electrical Engineering and preferably be Corporate Members of The Institution of Electrical Engineers. They should have had good industrial experience.

DEPARTMENT OF PRODUCTION ENGINEERING AND MANAGEMENT

(7) THREE—ASSISTANTS GRADE B IN PRODUCTION ENGINEERING to teach City and Guilds Machine Shop Engineering subjects to Final Certificate standard. Candidates should hold Final City and Guilds Certificates in Machine Shop Engineering and preferably be Graduate Members of the Institution of Production Engineers and/or the Institution of Mechanical Engineers. Ability to teach Sheet Metal work would be an additional advantage.

Salary within the range:—
Senior Lecturers... £1588-£1801 per annum.
Lecturers... ... £1408-£1601 per annum.
Assistants Grade B—
Graduates ... £828-£1486 per annum.
Non-Graduates £738-£1201 per annum.

Application Forms (foolscap s.a.e.) from the Principal, to whom completed forms should be returned within 14 days of the appearance of this advertisement.

C. E. GURR, M.Sc., Ph.D.,
SECRETARY TO THE EDUCATION COMMITTEE. B 813

UNIVERSITY OF BRISTOL

LECTURERS

Applications are invited for two posts as LECTURER (one Grade III and one Grade II) in the Department of Mechanical Engineering. The salary scales are now under revision and are likely shortly to be increased but the range is at present:—

Grade III, £700 to £850 per annum.
Grade II, £900 to £1650 per annum.
(according to qualifications and experience) with F.S.S.U. benefits and Family Allowance.

The duties will consist of lecturing, laboratory and tutorial work and the supervision of research projects. There are ample opportunities and facilities for personal research work in new and expanding laboratories.

Application (including the names of two referees) should be sent not later than 30th April, 1960, to the UNDERSIGNED from whom further particulars may be obtained.

H. C. BUTTERFIELD,
REGISTRAR AND SECRETARY.
B 811

THURROCK TECHNICAL COLLEGE

WOODVIEW, GRAYS

DEPARTMENT OF ENGINEERING AND SCIENCE

Required September, 1960:—
(1) LECTURER IN MATHEMATICS AND ALLIED SUBJECTS. The candidate appointed will be responsible for co-ordinating all mathematics studies in the Department. A University Degree and some teaching and/or industrial experience are necessary qualifications.
(2) TWO ASSISTANTS, GRADE B, to teach GENERAL ENGINEERING subjects to National Certificate and City and Guilds classes, with, possibly, the opportunity to specialise in one branch. Candidates should have good academic qualifications with some industrial and teaching experience.
(3) ASSISTANT, GRADE A, to teach MACHINE SHOP ENGINEERING to City and Guilds classes. Workshop experience essential and candidates should possess a Full Technological Certificate in Machine Shop Engineering or H.N.C. in Mechanical Engineering.

(These are new posts arising from expansion of the College.)

Salary Scales:
Lecturer £1370 by £35 (4) and £40 (1) to £1550 per annum.
Assistant, Grade B, £700 rising to £1150 per annum.
Assistant, Grade A, £520 rising to £1000 per annum.

For Grade A and B posts, previous industrial and/or teaching experience will be taken into consideration when deciding the commencing salary. The scales for these posts are also subject to additions for training and graduate qualifications if in accordance with Burnham Further Education Report conditions.

Application forms from the PRINCIPAL to whom they should be returned as soon as possible. B 805

BRIGHTON EDUCATION COMMITTEE

PRESTON TECHNICAL INSTITUTE

Required from September (new posts):—
1. GRADUATE LECTURER IN MATHEMATICS, for work mainly with part-time day O.N.C. and City and Guilds Final courses. Teaching experience with H.N.C. courses in Electrical Engineering an advantage.
2. GRADUATE LECTURER IN ELECTRICAL ENGINEERING, with experience of H.N.C. work in Electrical Technology and Machines. Work mainly with O.N.C. and City and Guilds Final courses.

Further particulars and application forms obtainable from the undersigned to be returned to the PRINCIPAL, PRESTON TECHNICAL INSTITUTE, COOMBE ROAD, BRIGHTON, by 30th April, 1960.

W. G. STONE,
DIRECTOR OF EDUCATION.
54, OLD STEINE,
BRIGHTON. B 807

APPOINTMENTS OPEN

REPRESENTATIVES

REPRESENTATIVE wanted by Manchester firm of Gear Cutters to take over the Midland area, in which they are already well established, on commission basis. A good knowledge of gearing would be required.—Replies giving full details of past experience will be treated in confidence.—BOX B 746, Offices of ENGINEERING.

UNILEVER

Applications are invited for the post of PRINCIPAL ASSISTANT TO THE CHIEF ENGINEER at their large factory in BOMBAY, INDIA. Candidates should have had a good practical training, with subsequent responsible experience, and be Corporate Members of the Institution of Mechanical Engineers.

Responsibilities will cover deputising for the Chief Engineer, administration and planning for new installations and for maintenance of factory equipment.

Tours are of two years' duration, with four months' leave. Special facilities are provided for married men and their families. Accommodation and medical attention will be arranged.

Written applications, with details of training and experience, to be addressed to HEAD OFFICE, STAFF DEPARTMENT (WF 55), UNILEVER HOUSE, BLACKFRIARS, LONDON, E.C.4. B 781

SENIOR AND INTERMEDIATE STRESSMEN

Expanding Aircraft Manufacturing Company situated in a pleasant part of the South of England require SENIOR AND INTERMEDIATE STRESSMEN AND ONE SENIOR STRESSMAN FOR TECHNICAL LIAISON AND APPROVAL OF CONCESSIONS. Also required is an Assistant Chief Aerodynamicist and two Senior Aerodynamicists. Salaries offered will be according to qualifications and experience and will range from £900 to £1500 for the Senior, Intermediate and Concessions Stressmen; £1300 to £1500 for the Assistant Chief Aerodynamicist and £1600 to £1300 for the Senior Aerodynamicists. New houses to rent will be offered to successful applicants.—Please send full particulars of experience, etc., to BOX AC 16652, SAMSON CLARKS, 57/61, MORTIMER STREET, LONDON, W.1. G 881

A FUEL TECHNOLOGIST

is required for Steelworks, Foundries and Silica Brickworks in the West Wales Section of Richard Thomas & Baldwins, Limited. Candidates should be Chemical Engineers and/or members of the Institute of Fuel, and be between 35 and 45 years of age.

Application forms may be obtained from:—
EDUCATION & TRAINING OFFICER,
RICHARD THOMAS & BALDWINS LTD.,
WEST WALES SECTION,
LANDORE, SWANSEA, GLAM.

B 801

EDITORIAL ASSISTANT

EDITORIAL ASSISTANT required for monthly journal specialising in world hydro-electric development. Should be young engineer (25-35), with qualifications and experience, preferably in civil or hydraulic engineering or in laboratory work. Aptitude for technical writing essential. Some knowledge of languages an advantage. Prospects of eventual editorship for the right candidate.—Apply: THE EDITOR, "WATER POWER," 33 TOTHILL STREET, S.W.1. B 760

BOILER ENGINEERS

BOILER ENGINEERS for commissioning and service work on latest type marine and land installations. Travelling involved. Required qualification is Ministry of Transport certificate or equivalent Naval ranking. Age range 25-40 years. Good conditions and prospects.—Apply in writing to STAFF MANAGER (T & S), FOSTER WHEELER LIMITED, 3, IXWORTH PLACE, S.W.3. B 730

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DESIGN DRAUGHTSMEN

Vacancies exist in a South of England Aircraft Manufacturing Company for SENIOR AND INTERMEDIATE DESIGN DRAUGHTSMEN, DRAWING OFFICE PROGRAMME ENGINEERS AND TEST HOUSE ENGINEERS. Salaries offered will be according to qualifications and experience and will range from £850 to £1250 for Senior Draughtsmen and Programme Engineers; £700 to £900 for Intermediate Draughtsmen and £700 to £1000 for Test Engineers.—Please send full particulars of experience, etc., to BOX AC 16656, SAMSON CLARK, 57/61, MORTIMER STREET, LONDON, W.1. G 880

MECHANICAL ENGINEERS

An expanding Company operating on a continuous process basis has vacancies for two well qualified MECHANICAL ENGINEERS in London and South Wales. Applicants should have sound experience in heavy engineering and in addition to their technical qualifications should have attained a good level of general education. The age limit is 32 and an attractive commencing salary is being offered. —Write stating brief details to BOX B 800, Offices of ENGINEERING.

OVERSEAS APPOINTMENTS

SIMON-CARVES LIMITED

REQUIRE

MECHANICAL ENGINEERS for overseas contracts. Applications are invited from men between 30 and 40 years of age who have experience in the erection and installation of electrical and heavy mechanical engineering plant, including H.P. compressors, pipelines and vessels. A.M.I.Mech.E. or similar qualification desirable.

Applications, quoting Ref. No. 32 with details of age, experience and qualifications should be forwarded to CONTRACT LABOUR DEPT., SIMON-CARVES, LTD., CHEADLE HEATH, STOCKPORT. B 803

FOR ADVERTISEMENT RATES, SEE TRADE TECHNICAL SECTION PAGE 3.

Companies

This Sales Graph is Vertical

CARRYING among the sprightliest advertising of anyone in the engineering industries, DESOUTTER BROTHERS (HOLDINGS) Limited could not be expected to resist the temptation to bring the whiskered managing director and his little horse into the annual report.

Significantly he is teamed with Mr. Squinch, the mechanical little chap now used in their subsidiary LANG PNEUMATIC's promotions. With suitably whimsical air the "MD" regards a motorway style road sign in which a thick black line leads vertically from the name Desoutter towards Lang Pneumatic.

And the black line could be mistaken for the sales figures. For the 1958 trading surplus, of £568,539, has been raised to £716,176 last year. Mr. G. H. Webb, the chairman, said in his annual statement that Desoutter sales increased by 14¼ per cent and Lang Pneumatic sales by 27 per cent.

Despite the substantial increase in sales during the year, outstanding orders are now rather higher than at the corresponding time last year. This being the case, the main factory is to be extended and more machine tools ordered.

One outstanding example of Lang Pneumatic equipment is its exclusive use in the new Thames foundry of the FORD MOTOR Company.

From its formation in 1951, the Desoutter Holding company has increased the net assets from £718,000 to £2,240,000.

Electronics Expansion by Simms Group

The Middlesex electronics engineers, CAWKELL RESEARCH AND ELECTRONICS Limited, have become a subsidiary of the SIMMS MOTOR AND ELECTRONICS Corporation.

Mr. A. E. Cawkell remains as a director and managing director.

Cawkell have developed a non-destructive test apparatus for materials and are responsible for the Remscope, an oscilloscope which provides a semi-permanent diagram on the screen. Widely sold in the home market, the Remscope has export sales to companies in Europe and in America.

Founded in 1947 by Mr. Cawkell, the company began with industrial noise measurement and later expanded into general electronics. By 1953 contacts existed with several Government departments and with industry.

Measurements for the Zeta project at Harwell and later thermonuclear fusion experiments were made with Cawkell equipment.

Rationalisation for Kent and Cam Gears

GEORGE KENT Limited are now to concentrate their manufacturing capacity and management effort on their industrial instrumentation, process control and mechanical meters, following the transfer of the STEERING GEAR Division to the ownership and management of CAM GEARS Limited.

Cam Gears are 40 per cent owned by George Kent. Additional strength has been added to Cam Gears by the purchase of 20 per cent of its stock by the ROSS GEAR AND TOOL Company of Lafayette, USA. Ross Gear are the largest independent steering-gear makers in the United States.

The instrumentation and meter interests of George Kent will continue from the plant at Luton and the subsidiaries and overseas representatives. The company expects that these rationalisation steps will speed up the pace of technical and sales development.

A Fall in Machine Tool Profits

Only two bright spots stood out in the otherwise disappointing annual report of the ASQUITH MACHINE TOOL Corporation.

They were the future improvement of results by the subsidiaries whose business is with the car firms, this was predicted by the chairman, Mr. Robert W. Asquith, and the setting up in Halifax, Yorkshire, of a new company jointly owned with a United States firm.

The Halifax company, WARNER, SWASEY ASQUITH Limited, manufacturing chucking automatics, is equally held with the WARNER AND SWASEY Company, of Cleveland, Ohio, USA.

Mr. Asquith reported a drop in last year's trading profit of the group to £563,475, from the previous figure, £815,105. At the time of the annual report, with six months of the financial year gone, the chairman declared that the picture was not encouraging.

The subsidiary companies which had among their output a proportion of standard machine tools were not obtaining sufficient orders to run their factories efficiently. Some traditional export markets were now closed. At home the demand just did not seem to be there.

Part of the Asquith results are explained by their heavy programme of development work and capital expenditure in enlarging and improving machine manufacturing facilities.

New £2 million Geon PVC Plant

The chemical company BRITISH GEON, which is 45 per cent United States owned, is to build a new pvc (polyvinyl chloride) plant at a cost of £2 million in extension to its existing pvc capacity at Barry, South Wales.

The output from the new plant has not been predicted but if it were to raise British Geon's annual pvc production of 30,000 tons by half, United Kingdom pvc total of 90,000 tons, reached last year, could be raised by almost 15 per cent.

The American interest in British Geon is held by B. F. GOODRICH CHEMICAL. The other 55 per cent being owned by DISTILLERS COMPANY Limited.

Distillers also own half of BRITISH HYDROCARBON CHEMICALS whose recent announcement of three new plants to be built includes one for making ethylene dichloride. So far pvc production in this country has been from acetylene but a substantial part of the United States output is based on ethylene dichloride.

The new moves in two companies in which Distillers have substantial interests could therefore bring this practice to the United Kingdom. It is an interesting chemical fact that pvc manufacture from ethylene dichloride results in hydrochloric acid as a by-product, and that acid can be used for the production of pvc from acetylene.

Pvc uses range widely, from curtains and raincoats to pipes and chemical plant fittings.

New Head Wrightson Furnace Division

HEAD WRIGHTSON PROCESSES Limited, a subsidiary of the Head Wrightson group, are in future to control their

increasing operations in the supply of furnaces to the chemical and petroleum industries through an Industrial Furnaces Division.

Among the varied Head Wrightson heaters and furnaces is one, the "Convetude" upshot heater, which is fired either by gas or oil. Their applications range over heat absorption from 300,000 to more than 60 million Btu per hour.

Head Wrightson Processes, whose chairman is Sir John Wrightson (inset), already conduct a number of special divisions which deal with their manufacturing interests and design in water purification plant and in cooling equipment.

Aluminium Consumption Improves in Britain

A 15 per cent increase last year in the United Kingdom's aluminium consumption is reported by the president of the Canadian company, ALUMINIUM LIMITED, Mr. N. V. Davis.

Aluminium use throughout the free world rose to record levels last year and as a result the company's Canadian smelters are now working at 90 per cent capacity. The British figure is particularly significant as it follows four years of declining aluminium consumption in this country.

Mr. Davis sets out the vast capital investment which Aluminium Limited, in company with other leaders in the industry, have been making in the past decade. The ten year total is more than $1,000 million, 1959's figure was $62 million, below the annual average because of the near completion of new hydro-electric and raw material facilities.

Aluminium Limited did not secure an expansion of its sales to British customers equal to the 15 per cent rise in consumption but its group sales other than to the United States, Canada and Britain were up by 51 per cent. More than half the aluminium imports into the European Common Market countries and almost three quarters of those into Japan came from Aluminium Limited.

Last year saw the major international aluminium producers making their market arrangements in Britain for expansion in the Commonwealth and European Free Trade Area markets. 1959 was also the fiftieth anniversary of the Canadian company's British subsidiary, NORTHERN ALUMINIUM, who this year and next are carrying through a major expansion policy.

Craftsmanship in a Fine Tradition

The metalworking and engineering firm of GEORGE LISTER AND SONS Limited, of Cambridge, has engaged in work as varied as the Lister-Jaguar and Lister-Maserati racing cars and the superb period restoration of the blacksmith Robert Bakewell's arbour at Melborne Hall, Derby.

Its Architectural Metalwork exhibition at the Royal Society of British Architects' galleries in London recently, showed a nice balance between methods both modern and biblical.

Developing their markets near at home in addition to remote export orders, the Lister craftsmen have restored or constructed gates and other metalwork for many of the Cambridge Colleges. Notable are the 18th Century gates of St. John's College, Cambridge, restored by the firm and a showpiece of a skill that is too often assumed to have passed.

Mr. George Lister told ENGINEERING that, contrary to some impressions, he had no difficulty in getting the right sort of boys to become apprentices. As he reflected, they must be of more than the general run of ability to realise that there is a definite place and a growing market for the traditional work of the blacksmith.

In an increasingly affluent society the Lister company may well have in its factory some advance evidence of what will be much more commonly seen household furniture and garden fittings within the near future. The beautifully finished wrought iron screen, at the moment a costly piece, could have a rapid progress to popularity as a division between the dining and lounge space of a through living room and blend with contemporary furniture.

Nothing is more up to date than some of the post-war development of Coventry. The Lister craftsmen have contributed, among other pieces, the 9 ft tall beaten copper coat of arms of the Belgrade Theatre and the unusually attractive cast iron panelled balustrading the shopping precinct.

For such a company a sympathetic eye on the past is to be expected. Reproductions of the work of the great English blacksmith Robert Blakewell are among the leading examples of the company's effort in this direction.

When the client wants it the iron or steelwork can be as functional and severe as to leave no doubt of its purpose. Some of the mild steel gates executed for local education authorities have an uncompromising bleakness that may appear symbolic to some of the less willing of those going into school.

Over the retail market at Coventry the ironwork and clockfaces put up in 1958 could enter a new "Unknown Political Prisoner" competition.

Gas Injection for Kuwait

A gas injection plant to be completed in the summer will reduce wastage of gas from the oil and gas separation process in an oil field, and will also facilitate crude oil production.

A NEW gas injection plant is being constructed by the Kuwait Oil Company Limited near to the centre of the Burgan Field which is in South East Kuwait.

Gas will be taken from the first stage of the oil and gas separation process at nearby gathering centres and compressed to a pressure sufficient to allow it to be injected into the underground oil reservoir. At present, about 100 million cu. ft per day of gas measured at normal temperature and pressure, is proposed at an injection pressure of 1,920 lb per sq. in (gauge). The injection pressure can be varied, and an ultimate condition of 72 million cu. ft at an injection pressure of 2,350 lb per sq. in is possible.

The gas enters the plant through a 24 in pipeline and is passed through an inlet scrubber to remove any entrained liquids. The main flow is then to the first stage compressor which receives gas at 375 lb per sq. in and 115° F and compresses it to 915 lb per sq. in, with a temperature rise of 255° F. Flow continues through air cooled intercoolers which reduce the gas temperature to 140° F. Subsequently, the gas passes through a scrubber which removes any condensates which have appeared in the first stage compression process.

The second stage of compression is identical but with gas inlet conditions of 900 lb per sq. in and 140° F and discharge conditions after cooling of 1,920 lb per sq. in and 140° F. After final scrubbing the gas flows to an injection manifold from which individual injection lines connect to five wells.

Each multi-stage compressor in this system is driven by a simple open-cycle non-regenerative single-shaft gas turbine which has a temperature rating of 7,000 h.p. In the Kuwait maximum ambient temperature of 120° F, the power available from each turbine is 5,950 h.p. at a speed of 5,740 r.p.m. This speed is increased through gear boxes to compressor speeds of 10,100 and 10,150 r.p.m. for the first and second stages of compression respectively.

The turbines are started by gas expansion turbines coupled to the main shafting system through pneumatically-operated clutches. These turbines use gas at 400 lb per sq. in from the inlet gas scrubber which comes through a utility gas system. It is expanded through the turbines out to atmosphere to accelerate the main turbines up to firing speed. The combustion chambers of the main turbines are supplied with gas at 150 lb per sq. in gauge from the fuel gas system and after firing the starting turbines disengage and the main turbines are run up to full speed and power.

The electricity supply is 440 V, 3 phase, 50 cycle a.c. It is used for the plant controls and electrically driven auxiliaries. In the event of a supply failure, an emergency 75 kW diesel generating set is automatically started and connected to the emergency distribution panel. In addition to this system, there is a 125 V d.c. supply from batteries which can be used for the electrical control system and emergency equipment.

Air for operating instruments and controls is obtained as a bleed from the main driving turbine axial flow compressors. At other times and during start-up, the air is supplied by an electrially driven air compressor.

Oil is used to operate the main plant block valves, re-cycle valves, plant pressure reducing valves and all major gas valves; the re-cycle valves being equipped with hydraulic positioners and operators. An electrically driven oil pump delivers oil at approximately 450 lb per sq. in to an oil supply header. From the header, the oil is distributed to the hydraulic valve operators and to the pressure control valve positioners and operators. The re-cycle valve positioners receive a supply from a low pressure header which is fed through a pressure reducing valve. In addition, hydraulic accumulators provide an emergency oil supply for operating critical valves which must be functioning during emergency shut-down.

The gas used in the plant is both odourless and colourless and, therefore, special measures are necessary to detect and warn operating personnel of dangerous concentrations of gas. This is taken care of by a combustible gas alarm panel which is fully automatic in operation and which monitors the atmosphere at six strategic points round the plant. Detection of a combustible mixture of gas and air at any of these points results in the sounding of an alarm at the panel and on the station alarm system. Steps can then be taken immediately to shut down and vent the plant to atmosphere. Fire protection is provided by dry chemical extinguishers, carbon dioxide extinguishers and hoses.

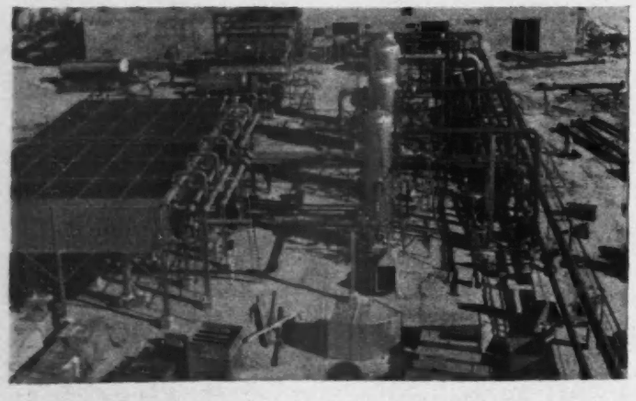
The compressing equipment is housed in a steel frame brick clad structure approximately 154 ft long by 56 ft wide on two main levels. The ground floor houses the switchgear room which contains the terminal pipework to and from the turbines and compressors as well as the turbine compressor, filtering equipment and ducts. The turbines and compressors occupy part of the first floor, the remainder housing the control room, the nerve centre of the plant, and offices. A double glazed partitioned wall separates the two sections which are held at an air pressure differential of 0·2 in water gauge. The space above the control room forms a local second floor where pressurising air fans and duct works, air conditioning equipment and air filtering equipment is situated.

The whole plant is controlled from the pressurised control room in which is located the turbine control duplex and graphic flow panels. Signals from instruments located throughout the plant are received at this panel and automatically translated to show the positions of valves and operation of the main plant components by means of indicating lights. Manual positioning of the controls prior to start-up is effected on this panel, together with the start-up of the turbines and subsequent loading of the compressors.

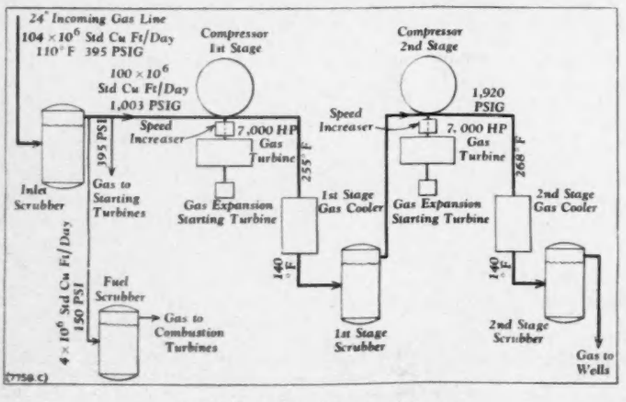
During automatic operation the panel will give the operator a complete picture of all functions of the plant and should any gas leakage, or other untoward event occur, warning and indicating alarms and lights show which component of the plant is being affected. If it is impossible to rectify the trouble manually, or if the operator is not available, the whole plant will shut-down automatically and the gas system vent to the atmosphere.

The whole installation has been designed to give the maximum degree of automatic control and safety; enabling one man to start, load and operate the plant under normal conditions. This is done by the metering, recycle, pressure relief and venting systems which are preset from the panel for specific operating circumstances.

An aerial view of the Kuwait Oil Company's new plant. No space problem here.



The process area showing the tall cylindrical gas scrubbers and coolers.



A simplified flow diagram of the gas.

Mechanised Casting for Glass Moulds

A mechanised casting plant which has just started operating is the first in the glass industry. Its main purpose is to make cast iron moulds for glass moulding machines.

THE casting plant is at the Preston works of Dilworth and Carr Limited, a subsidiary of United Glass Limited. The main interest of the company is in the manufacture of machines for the glass industry, although they are known also as manufacturers of tight bends for large diameter pipes, such as those found in power stations. The output of the new plant is mainly moulds for glass moulding machines and castings used in the manufacture of their own machines.

The idea of installing a mechanised casting plant was first contemplated some 18 months ago, when it was found that this technique had not been applied in the glass industry of this country. So far as this particular industry was concerned, the whole process of manufacturing mould castings was heavily shrouded in secrecy and " know how."

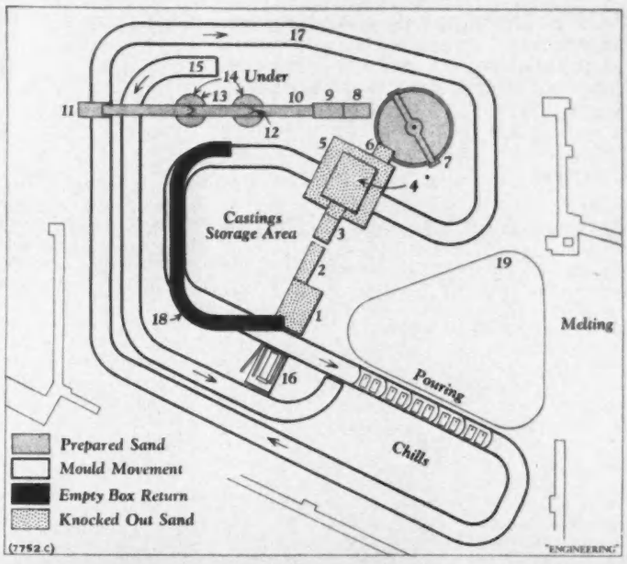
As a first step towards mechanisation, it was decided to make the castings using plate moulding methods. This entails mounting the patterns on to a plate on to which the moulding box pins fit exactly.

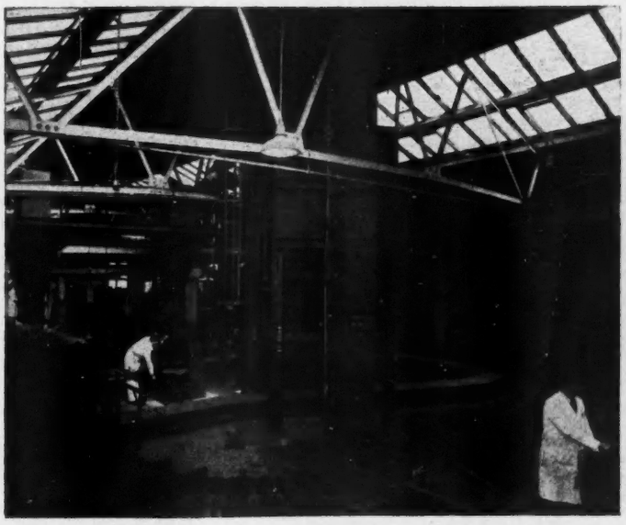
After this method of casting had proved itself, Foundry Mechanisations (Baillot) Limited of Bletchley, Buckinghamshire, were called in to study the mechanisation of the process and a scheme was drawn up which allowed a nine man team to produce 50 pairs of mould castings per hour. This represents a great improvement over the previous method which produced one pair of castings per man in 45 minutes.

The plant is equipped with two mould machines, both capable of moulding 50 boxes in an hour, thus producing 50 pairs between them in an hour. In operation the pattern is mounted on the mould machine and the box is fixed on to it before a chute on a hopper situated above the machine is opened to allow prepared sand to fill the box. The machine shakes the box to ensure that it is properly filled before the sand is compressed uniformly over the pattern. The box is then vibrated at high speed to loosen the pattern after which the machine withdraws the pattern from the box.

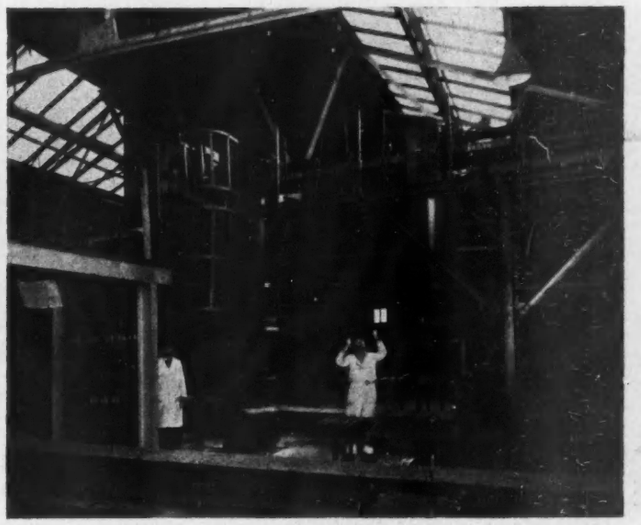
The layout of the casting plant.

1 Vibrating knock-out.
2 Belt conveyor.
3 Belt and bucket.
4 Rotary screen.
5 Storage hopper.
6 Feeder belt.
7 Sand mill.
8 Belt and bucket elevator.
9 Cage-type disintegrator.
10 Belt conveyor.
11 Surplus sand chute.
12 Deflectors with side chutes.
13 Conical hoppers.
14 Straight-draw mould machines.
15 Mould track.
16 Pneumatic mould pusher.
17 Mould conveyor.
18 Empty box return track.
19 Overhead pouring runway.





The new mechanised casting plant. The conveyor in the foreground carries the empty boxes back to the mould machines after they have been knocked out.



Operating the deflectors which control the flow of rejuvenated sand to one of the mould machines. The structure on the left is the sand mill.

The box is next pushed along a gravity conveyor to a powered conveyor where it is closed and placed on the plate. The conveyor can hold 200 boxes along the 225 ft of track. It stops every 15 ft to allow pouring into the moulds. When a box has completed its circuit on the conveyor. a pneumatically operated ram pushes the box off the conveyor on to a vibrating knock-out which shakes the sand from the box on to an underground belt. The empty boxes are then returned to the mould machines on a second gravity conveyor and the castings are stored before final processing.

The underground conveyor carries the knocked-out sand to an elevator which deposits it in a 10 ton storage hopper. From the storage hopper, the sand passes into a mixer which prepares and rejuvenates the sand for re-use. From the bottom of the mixer, the sand is carried up an elevator to a delivery conveyor fitted with deflectors which guide the sand into small storage hoppers above each mould machine—and then the sequence begins again. It takes four hours to mould and cast 200 boxes of moulds.

During 1959, a complete " Stemware " (stemmed glass) manufacturing plant was made by Dilworth and Carr which will use the moulds from the new plant. It was for the Ravenhead factory of United Glass and it includes a Westlake machine for producing stemware bowls and weighing in the region of 30 tons.

The automatic machine sucks glass from a tank on to the moulds which are removed from the machine by hand when processing is complete and loaded on to a conveyor running to a press which presses the foot on to the bowl. The press is a rotary transfer machine with 12 stations controlled by a Geneva cam.

The glass and foot are then removed from the moulds by hand on to an automatic conveyor which dispatches them to the foot former. This loads the bowl and foot straight into a set of spinners. The glass then passes through a set of heaters which grip the foot and spin it out flat. They are next loaded into a machine which burns off the excess glass on the bowl and forms a neatly radiused edge to the glass. This plant can produce between 50 and 60 finished glasses a minute.

Beating Ice Packs in the St. Lawrence

Winter navigation of the St. Lawrence Waterway is not practicable at present above Quebec City, but an investigation by a Canadian engineer has shown it to be technically feasible, right up to Lake Ontario.

This is the sort of ice which can build up into jams if steps are not taken to prevent it.

PORT AUX BASQUES, Newfoundland, can be regarded as the sea terminal of the St. Lawrence Waterway, as it is open to ocean traffic all the year round, except occasionally for a few days in the spring when Gulf ice is being swept out to sea. Main Duck Island, Lake Ontario, is a convenient inland terminal when discussing winter navigation, as it is on the eastern edge of the main deeps of the lake, which do not freeze over at any time of the year. Between these two points the distance is some 950 miles, of which the St. Lawrence Seaway, from Longueuil turning basin below Montreal Harbour to Main Duck Island, occupies 192 miles. Before the Seaway was completed, ocean-going ships could navigate up to Montreal; with the completion of the Seaway, navigation right through to Lake Ontario became possible during the summer. But for about four months of the winter season ice prevents ships from passing beyond, at present, Quebec; this city is reached with some difficulty, but not nearly as much as was hitherto expected. If the Waterway could be opened to shipping to Montreal and beyond throughout the year, the annual capacities of the inland ports would be increased by as much as 50 per cent.

After a detailed investigation of the problem, Mr. Winnett Boyd, of Winnett Boyd Associates, Toronto and Montreal, has shown that from an engineering point of view it is perfectly feasible to beat the ice problem. His solution involves the use of a variety of engineering methods. The cost would undoubtedly be considerable,but the benefits would be more than commensurate. Political considerations would also be involved, since the works needed to protect the Waterway would, in parts, be in the territories of two nations, Canada and the USA, but the same applied with the Seaway, and that is now an accomplished fact.

For the purposes of the survey, the Waterway was divided into five sections; the Seaway (Lake Ontario-Montreal), the river section (Montreal-Quebec), the estuary section (Quebec-Saguenay River mouth), upper Gulf of St. Lawrence (Saguenay River-western tip of Anticosti Island) and the lower or main Gulf portion (Anticosti Island-Port aux Basques). Suitable techniques for keeping each of these sections navigable during the winter have been devised.

ICE JAMS THE CHANNEL

Government ice-breakers keep a winter channel of sorts open from Montreal to the open waters of the estuary. This is not suitable for commercial navigation, except in exceptional circumstances, being intended to minimise winter flooding due to ice jams. It does, however, show that it will be possible to keep a navigable channel open.

Lake Ontario never freezes over, neither does the St. Lawrence estuary below Ile aux Coudres. Water from Lake Ontario flows steadily down the St. Lawrence River all through the winter, the maximum thickness to which ice will grow in the sheltered bays does not exceed about 26 in, and there are substantial stretches of open water.

It is ice jams which stop navigation. They are caused by an accumulation of surface ice which breaks off progressively from the ice sheets over the stagnant reaches of the river and lakes and is carried downstream to collect in the slow-flowing basins with restricted outlets. Here the accumulations are cemented together by tenacious frazil ice (colloidal and/or fine crystalline ice dispersed throughout a mass of water; it is formed in swift-flowing shallow water). Once a jam has started, it grows rapidly, and in the Sorel section of the river below Montreal, ice jams (sometimes called hanging ice dams) normally reach a maximum depth of 50 ft; they have been known to reach 90 ft.

Prevention of ice jam formation is the primary object of any scheme to permit winter navigation. Attention has also to be given to a number of other sources of difficulty, and the answer to all-year navigation is to apply a variety of remedies and preventives.

In the first place, ice jams must be prevented by impounding the surface ice outside the navigation channel, and by eliminating the " breeding " areas for frazil ice. Secondly, the surface cooling area must be reduced as much as possible, to help the channel to keep itself ice-free. Thirdly, where the current is insufficient to prevent ice formation, air bubbler systems must be installed to bring the warmer bottom water to the surface. Fourthly, the Seaway locks must be kept operational; this can be done by using the condenser cooling water from thermal power stations. Finally, the harbours must be kept open by air bubbler systems.

In the preliminary investigation, consideration was given to the possibility of using the river current for producing the power required to operate air bubbler systems. It was established that the minimum current which will prevent sheet ice formation was two knots. This would be insufficient to provide the power required without uneconomically large equipment. Use of the river current was therefore rejected.

In its passage from Lake Ontario to Montreal the St. Lawrence Seaway passes through several lakes, where the area of water exposed to cooling is very great. To regiment the water flow, impound the ice and reduce heat loss, two main constructional features are needed; rock barrages in appropriate positions to impound the surface ice and restrict the water flow, and floating ice booms to accomplish the former only, where the barrages are not practicable. Barrage and ice boom plans have been worked out in detail. As an example of the ice boom work needed, two floating booms 13½ miles long, with an air bubbler system, would define and protect the navigational channel through Lake St. Lawrence. Similar arrangements would be necessary in Lake St. Francis, Lake St. Louis, Lake St. Peter and some other parts of the Waterway.

To deal with the problem of freezing in the Waterway locks, thermal power stations would be built, which would discharge their condenser cooling water into the lock forebays. Weirs would allow surface ice to be spilled past the locks. Construction of these power stations would fit in with the expanding power needs of the areas adjacent to the Seaway.

BOOM GUARDS

In the river section, from Montreal to Quebec, the most important consideration is the elimination of frazil ice. To control this source of trouble, two dams and power stations would be built at Upper and Lower Lachine, at the lower end of the Seaway. The Upper Lachine works would eliminate the Lachine Rapids as a source of frazil ice and successfully impound the surface ice of Lake St. Louis. The dam would make available 32 ft head of water for power generation.

At present, the Lower Lachine power station is not considered economically feasible because of winter back flooding. But a control dam at this point would be needed to eliminate the last breeding area of frazil ice, and this would, in turn, aid in preventing downstream ice jams, thus making this power station economical.

Some rock barrages would be needed below Montreal, and the navigation channel in Lake St. Peter, which is shallow and sluggish, would need straightening. Floating ice booms and air bubbler systems would also be needed. By means of these works the river current in the navigation channel would be increased, and any floating ice would tend to be carried right through, the wind having less effect on it. Surface ice would be impounded by the floating booms, and any ice which might form in the channel would be separated by the bubbler systems, broken up by ships using the channel, and carried away by the current.

Below Lake St. Peter few difficulties are expected and the two ice-breakers at present working in the Montreal to Quebec section should prove more than adequate for keeping the channel fully navigable.

Montreal and Quebec harbours are in the river section, and as these include areas of still

The channel is clear and an ocean-going freighter heads towards the sea.

water, complete air bubbler systems would be installed.

In the estuary section from Quebec to the Saguenay River, only that part extending from Quebec to the eastern end of the Ile aux Coudres presents any difficulty. Downstream of the Ile aux Coudres the water depth increases rapidly and the effect of warm water from the Laurentian current is felt. To keep the river open from Quebec to Ile aux Coudres two ice-breakers would need to ply daily between Quebec and Pointe au Pic and to convoy merchant vessels through when necessary. Two ice-breakers are already employed on this section and no increase in operating costs would be involved.

Below the Saguenay River three great currents merge, and their effect is to keep the north shore clear of ice. They do, however, tend to pile the ice on the south shore, thus closing the ports on this shore to navigation. As the north shore ports are the important ones in this section of the St. Lawrence, nothing more is needed here than weather reporting and the occasional services of an ice-breaker. If a south shore port were to be kept open during the winter season, major construction works would be necessary, including bubbler systems.

In the lower, or main St. Lawrence Gulf, two great contra-flowing currents are the main characteristics. The westerly-flowing Laurentian current in the north has a warming effect, and keeps the southern Newfoundland ports open, but the easterly-flowing Gaspé current transports vast quantities of ice from the Upper Gulf to a central ice pack and the great bay bounded by Cape Breton Island and the Gaspé peninsula. To make deep sea all-year navigation possible through this section of the Gulf, regular weather reporting, aerial ice patrolling and other navigational aids such as radio-telephony would be needed. In addition, two powerful ice-breakers would be required and a third would keep channels open into the New Brunswick ports on the Bay of Chaleur.

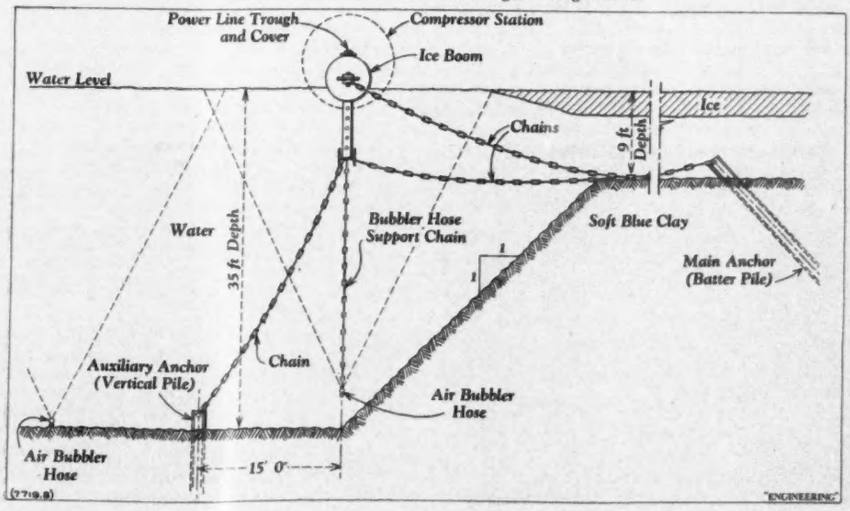
Rock barrages to control the flow of a river pose no great engineering problems. The use of power station condenser cooling water to keep lock chambers above freezing point is logical, and the power stations themselves fit in with an expanding economy which is going to need them anyway. Ice-breakers, aerial ice patrols and weather forecasting are all, of course, in regular use, and would simply be incorporated into the larger, overall plan.

The use of floating ice booms and air bubbler systems, though more unusual, again offers no special problems.

For the St. Lawrence project the floating ice booms are designed to extend both above and below the water, so that ice will be held firmly behind them and can neither ride over nor slip under. They would replace normal navigation markers, and could be fitted with navigational lights as required. To keep their cost to a minimum they have been designed in as simple a form as possible, and would be made in 40 ft lengths so that they could be transported by rail. Each section would consist of a flat-ended shell 5 ft diameter, 38 ft long, with a rack projecting 6 ft 9 in below it. This rack would be made of standard steel piping. At each end of the boom section there would be eyes and clevises, for joining it to the adjacent sections; these fittings would bring the total length up to 40 ft.

As the ice booms would, in most cases be moored in lakes having clay bottoms, friction piles would be used in place of conventional anchors. There would be a main anchor for resisting ice pressure and an auxiliary anchor for maintaining location.

Lake St. Peter ice boom anchorage arrangement.



BUBBLE SYSTEMS

The air bubbler system, developed by the Swedish Atlas Copco organisation is also in practical operation in several parts of the world. In Lake Malaren, Sweden, for example, an air bubbler system 4½ miles long keeps the lake surface free from ice, which is normally 20 in thick. The water depth varies from 45 to 90 ft. This installation may be extended in the near future to 66 miles.

It has been established that the width of the water surface cleared is about equal to the depth of the distributing pipe. Pipe orifices of ⅛ in diameter are adequate, and the spacing of the orifices along the pipe must be equal to the pipe depth. An air pressure differential of about 15 lb per sq. in is required at the pipe orifices. Thus, for a pipe anchored at about 1 ft from the bottom of the 37 ft St. Lawrence ship channel, which is considered the best position, the air pressure required will be 15·6 lb per sq. in (the water pressure at 36 ft) plus the 15 lb differential required, giving a line pressure of 30·6 lb per sq. in; to this an allowance must be added for line losses. It is obvious that the provision of compressed air for the bubbler system line presents no difficulties. With the orifices placed at 36 ft centres, there will be 147 per mile, and the air required per mile of bubbler pipe will be 55 standard cu. ft per min. Making suitable allowances for losses and overall efficiencies of motor and compressor, the electrical power needed per mile of bubbler pipe is 8 h.p.

It is proposed that for the floating ice booms a bubbler line should be laid immediately below each boom, which would ensure that the boom itself would float normally in clear water. This would prevent ice pressure from building up against the booms as a result of temperature fluctuation; the only ice which would touch the boom would be that which had broken away from the main sheet. Taking into consideration the complete pipe run in a boom-protected navigation channel, it would be possible to install compressor stations at two mile intervals in 10 ft diameter boom sections, each compressor feeding four miles of pipe, with an air requirement of 220 cu. ft of free air per min.

Engineering solutions exist for all the conditions. Economically, one important fact stands out. By 1980 in Ontario alone, the cost of the coal stocks which have to be accumulated in the autumn for power generation during the winter, will have made all-year lake navigation a necessity.

Acknowledgement is made to Mr. Winnett Boyd, whose report is the basis of this article.

On the Shelf

By Frank H. Smith

Had a 'phone call the other week from an agitated Big Library. They wanted to know if I had a certain French work on guided missiles but I had to admit that as the price was rather in excess of that charged for a smuggled copy of a banned work I had not, so far, plucked up courage to buy it. Pity, they said, because they had bought it and, when it arrived, found that about 30 pages had been cut out and they wanted to know why. No doubt it is because of some security angle but it does seem a bit 'ard when you pay very good money for an erudite book and then find it has been treated like a collection of dirty postcards.

One good thing that seems to arise from the Oxford and Cambridge concern over Latin is a realisation that English is not all that it might be. Which is an excuse to mention Heinemann's " English in Schools " series of which Book Five is now ready. This completes their secondary course. The fact that it is illustrated by Anton (who cannot be said to be an artist with a very serious vein) makes it sound as though it might even be attractive to a schoolchild coming up to teenagency. Funny how often one comes across items, these days, about which one can say " If only they had had this sort of stuff in my day ".

I'm not sure whether I got this direct or from Collets. *Bulletin*, January, 1960, comes from the Publishing House of the Czechoslovak Academy of Sciences, Foreign Department, Vodickova 40, Praha 2. The " c " in the street name has a little new moon on its back over the top. The subtitle of the *Bulletin* is " What's new in Czechoslovak Science? " and the publications cover six subjects from the Prague house and five from the Slovak Academy of Science, which is in Bratislava. I think it's from Collets because in the same pile I found their amendment list to their subscription catalogue of items from the USSR.

Commended to the notice of all editors of periodical literature with any pretensions to technicality is " Alternatives to the Scientific Periodical " (a report and bibliography) in *Unesco Bulletin for Libraries*, March-April, 1960 (HMSO, 3*s* 6*d*). The authors are the director and the order librarian of the Engineering Societies Library, New York, and they deal, in plain straightforward language, with all those questions of to preprint or not to preprint, delays in publication, length of paper, reaching the reader, and so on. A collection of 121 references should help you on your way.

There is quite a long list of new books on ships and boats from Adlard Coles, the publishers who specialise in the water-borne. George Harrap and Company Limited, of 182 High Holborn, London, WC1, are their distributors, and Harrap themselves have a couple of attractive catalogues. One deals with the fiction and young people and the other with educational books.

Stand back and get out the dikker. *Catalogue des Publications* from Office National d'Etudes et de Recherches Aeronautiques at 29 Avenux de la Division Leclerec, Chatillion-sous-Bagneue (Seine). It goes without saying that aéronautiques covers many more things than aëronautiques. It's bi-lingual, by the way.

Still waters run deep but Bowaters run a paper organisation that is a household word. On the occasion of the opening of a new sulphate pulp mill by Bowaters Carolina Corporation they have produced a most attractive book called *Bowaters in North America*. This is one of those publications that delight me, with beautiful photographs, distinguished type and delight-to-handle paper (Bowaters " Cotinex " *s/o DC* 60 lb, in case you want to know). Londoners will know their place but others may like to apply for a copy to Bowater House, Knightsbridge, SW7.

Electron Paths

Principles of Electronics. By H. BUCKINGHAM and E. M. PRICE. 2nd Edition. *Cleaver-Hume Press.* (17*s* 6*d*)

Instruments Electroniques de Mesure. By E. H. W. BANNER. Translated by M. BOUVIER and A. MAITRE. *Dunod, 92 rue Bonaparte, Paris VIe, France.* (5,400 F)

Industrial Electronics Handbook. Edited by WILLIAM D. COCKERELL. *McGraw-Hill, New York and London.* (174*s* 6*d*)

Principles of Electronics is the second edition of a textbook intended primarily for the general electrical engineer or student. Chapters on transistors and magnetic amplifiers and a set of test questions with numerical answers have been added. About a quarter of the book is a concise theoretical treatment which assumes some knowledge of a.c. and d.c. theory. It is an admirable summary and the authors are careful to point out where their treatment is incomplete or oversimplified.

The quarter devoted to electronic devices is less balanced. In a revised edition which describes klystrons and the special suitability of disc-seal triodes for higher-frequency applications one might expect at least a passing reference to travelling-wave tubes. It is, however, extremely difficult to write anything other than a short paper on this subject without omissions, and in a book of this size it is perhaps more surprising that so little is omitted.

The rest of the book deals with methods and applications. It ranges widely and the treatment is largely theoretical. This is definitely not a book for the specialist but should prove, with its additional chapters, an adequate general introduction to the subject. There are no photographs, but the line drawings are excellent.

Instruments Electroniques de Mesure contains photographs which illustrate the point made by the publishers of *Principles of Electronics* that drawings are generally much more helpful. Although a photograph of a rectangular box showing some controls and the maker's name (prominently) may be of help to the manufacturer it is difficult to see of what use it can be to the average reader. This French edition of 494 pages as against 395 pages for the original English edition has been lengthened by the additional photographs, but the bibliographies have also been usefully extended.

The translation has been made with a conscientious respect for the text (essential in so specialised a field), yet with a feeling for style which is sometimes absent in similar translations into English. A small point which is frequently irritating in translations is the preservation of original equipment nomenclature without details of equivalent equipment or components obtainable where the book is read. But even without this information the book should still be as useful to French instrument engineers or users as the original has proved to be in this country.

The *Industrial Electronics Handbook* is the 56th of this well known series to be made available in the United Kingdom. It is a practical book, with emphasis on functions and applications rather than theory, and only eight of the 102 contributors are from academic institutions, the editor having drawn heavily on his colleagues in the General Electric Company of America.

Theory has not been neglected and about a fifth of this 1,408 page book is devoted to fundamentals. It is largely written by the eight academic contributors and summarises most of the fields in theoretical physics and engineering relevant to the problems of the electronic engineer. The results and formulae are expressed in usable forms, all formulae having practical dimensions, and sources are given in most cases.

The mathematics section contains a particularly valuable chapter on feedback-control-system theory and there is an elegant differentiation between the Heaviside operational method and the use of Laplace transformations. (One welcomes the attention to detail which provides four pages of Laplace transforms but one questions the need for two pages of instructions on the use of a slide rule.)

It has long been accepted that an understanding of the parallel hydraulic, pneumatic and mechanical principles is useful to designers of electronic control systems. Mr. Cockerell recognises its necessity, providing a grounding in the fundamentals of mechanics of solids and fluid and gas flow, supplemented by information on mechanical, hydraulic and pneumatic control elements. Electrical control elements are described in considerable detail and there is a useful list of representative transducers.

There are authoritative sections on power supplies, control circuits and circuit applications, although some applications, such as high-frequency heating, receive sparse treatment. The mechanical design of equipment is comprehensively treated, including a good section on ergonomics. One feels that a designer making full use of the information provided here, and elsewhere in the book, would have little trouble in meeting the hazards described in the section on users' requirements. Typical of the editors' conscientious approach are details of the differences between British and French practice and that obtaining in the United States.

Indexing is thorough, bibliographies generally comprehensive, and terminology and symbols are standardised through a wide range of styles. The publishers say with some justification that this is " a master handbook of descriptive and reference material covering all phases of industrial electronics and control." At £8 14*s* 6*d* it is still value for money.

GORDON WARRINGTON

German Workshops

Hydraulische Pressen und Drückflussigkeitsanlagen. By ERNST MÜLLER. Vol. 3. *Springer-Verlag, Heidelberger Platz 3, Berlin-Wilmersdorf.* (43·50 DM)

Volumes 1 and 2 in this group of books by Ernst Müller dealt with presses for forging and dropforging (Vol. 1) and for the production of steel tubes, hollow bodies, plates and sheets (Vol. 2). The present volume deals with presses and hydraulic installations for non-ferrous materials—in particular for the extrusion of lead pipes, cable sheaths, lead wire and resin-covered solder wire.

Of a basically practical nature, the book is well written and illustrated, with a minimum of mathematical treatment, though essential calculations, as of stresses, piston pressures and other design data, are adequately covered. Very useful information is given on die design and materials, and worked-out examples in the final chapters cover the design of cylinders and columns, and the determination of design parameters for various types of press. Pressure pumps, accumulators and control systems are treated in separate chapters, to complete a comprehensive review of the equipment available, and its principal design features.

As a practical handbook covering the whole field of this rather specialised subject, the present volume should be of value to designers of presses and tools, as well as to students and others in search of practical and theoretical information. It should also serve as a reference book for those responsible for purchase and maintenance of the type of hydraulic equipment described.

Kerbspannungslehre. By H. NEUBER. *2nd edition. Springer-Verlag Heidelberger Platz 3, Berlin-Wilmersdorf.* (36 DM)

Dr. Ing. H. Neuber is an acknowledged authority on notch stress theory, and his name alone is sufficient recommendation to this book. With increasing knowledge of the behaviour of materials of construction, the growing demand for more efficient design, and the use of higher stresses, the designer is faced with the need for more exact knowledge of the influence of notches and other surface conditions.

With a few exceptions, previous methods of calculation of the effect of notches have been based on two hypotheses; on the one hand there is an idealisation of shape, and on the other the material is treated as ideal, and following Hooke's law at the higher stresses. The present edition of the book deals not only with the fundamental laws, but develops a non-linear elasticity theory in integral form, by means of which the effect of the departure of the material from Hooke's law can be understood.

Basic theories of stresses and simple notches are dealt with adequately in the early chapters, before the text moves on to expand the theories and to discuss the complexities of the problem. Particularly well-drawn diagrams are provided, from which a reader can identify very readily a specific problem in which he may be interested.

All the types of notches likely to be encountered in practical design work are covered, and the information on internal notches and voids is particularly useful, though it is somewhat difficult to visualise how the theory can be applied in practice, owing to the idealisation which has had to be adopted. A series of worked-out examples is given at the end of the book, and set of diagrams provides examples of notch stress and shows shape factors graphically; these diagrams are in a separate pocket, which makes easy reference possible, but does introduce the risk of their becoming mislaid.

Schweisstechnik. By ERICH SUDASCH. *2nd edition. Carl Hanser Verlag Kolbergerstrasse 22, München 27.* (65 DM)

In bringing the subject of welding up to date in this, the second edition of a well known book, Dr. Ing. Sudasch, one of the best known German authorities on welding, has tackled a very big subject. He has, in fact, almost entirely rewritten the book, and a bibliography, covering 24 pages and containing 706 references, gives some indication of the ground covered. The result is a book which is not simply a ready reference manual of welding; it is worthy of much more detailed study.

Iron and steel metallurgy, with particular reference to welding properties, is discussed in detail, and well illustrated by reproductions of microstructures; constructional steels, alloy steels, steel castings, cast and malleable irons are considered in this section of the book. After this detailed theoretical introduction, the author proceeds to deal first with electric arc welding, developing the subject from basic principles to a consideration of welding equipment, electrodes and examples of work done by this method. Following the same pattern, the book then goes on to deal with gas and gas fusion welding A chapter is devoted to atomic-arc, argon-arc and other special welding techniques, and resistance welding is also dealt with in the same comprehensive manner.

This first part of the book can be considered as a general review of the present state of the technique of welding. It is followed by chapters devoted to detailed consideration of welding various materials such as non-ferrous metals, plastics, clad metals and other special applications. Gas cutting, flame hardening and even soldering are covered fully. Design of components for welding is dealt with adequately and well illustrated by diagrams, and there are chapters on strength calculations and cost computation. Details of tests and test methods are given.

The main criticism of the book is that the author has covered such a wide field and has incorporated so much material that it is a little unwieldy to use. On the other hand, such a complication is unavoidable in a book which sets out to be a really comprehensive review of the subject of welding; this it certainly is.

A. BINNS

Atomic Jurisprudence

Progress in Nuclear Energy: Series X. Law and Administration. Vols. 1 and 2 Edited by HERBERT S. MARKS. *Pergamon Press.* (£9 9*s*)

There is an Athanasian ring about the assertion that this single volume comprises two volumes and one cannot but be sorry to see this trivial but unnecessary adulteration of a word. The fact is that this book of 996 pages is divided into two parts, first a collection of 11 articles and secondly a collection of the laws of several countries (but unfortunately not all) which relate to nuclear energy.

I can reveal at the outset that I have profited greatly from perusing the book and have enjoyed much of it. The subject matter—the manner in which legal systems have grappled with the administrative problems which the new form of energy has posed—does not make for light literature and there must be very few persons whose favourite bedtime reading is to be found in statute law (although it usually has remarkably soporific value when ingested in large doses).

Lawyers in the United States are much more interested in jurisprudence than their brothers in this country. There is obviously more scope for the philosophical study of law in federal countries than in those with a single legal system. In this country we do not customarily regard ourselves as living in a federal state although we have three legal systems, omitting the law practised in the Isle of Man and the various Channel Islands. In the United States there are now no less than 50 separate states, each with its own system of domestic law; and the subtle differences between each provide a kind of hotbed for the propagation of a scientific study of the fundamental principles on which justice (in the broadest sense) is based. Accordingly, there has been much interest shown by lawyers in the States about atomic energy and a spate of essays and papers has poured out on the way in which nuclear energy, with its great and imperceptible means of causing damage to living beings over a widespread area, can be fitted into the existing systems of law, which necessarily were framed in the days when the best authority on the atom was Lucretius's *De Rerum Natura.*

It need therefore cause no surprise—and, indeed, is in a sense a guarantee of erudition—that the editorial board of this book, under the chairmanship of Mr. Herbert S. Marks (who was at one time general counsel to the United States Atomic Energy Commission) is composed of citizens of the United States. Their task has been admirably performed and it is no fault of theirs that the second half of the book is not as complete as one might wish. But as events move so fast in the field of atomic energy, readers should not lose sight of the fact that the book does not take account of any changes which have occurred since the middle of 1958.

Volume I gets off to an excellent start with an article on atomic energy law in the United States by the Dean of Columbia College, Mr. J. G. Palfrey. Here is explained vividly the background of the political scene in which the US Atomic Energy Acts of 1946 and 1954 were born and have developed, and Mr. Palfrey tells a fascinating story of the difficulties involved in establishing machinery for federal control over a subject for which the founding fathers omitted to provide in their federal constitution. In 1945 it was simple to place emphasis on the defence aspects of atomic energy; but the way in which the whole subject was not merely veiled, but swaddled, in secrecy must now seem astonishing. Under the Act of 1946 (section 10) even officers of the Defense Department had to obtain a special clearance from the Commission before they were qualified to learn anything of what the Commission was doing in the military field. Not unnaturally the communication of any information to foreign countries was made impossible. It is a credit to those who were concerned in the early days with atomic energy that the new infant was not strangled by the safeguards which were provided. Here too, the curious relationship between the Atomic Energy Commission and the Joint Congressional Committee on Atomic Energy, which has given rise to serious clashes of temperament, is described. The Commission has five members, charged with the general conduct of research and development in atomic energy, but it is brooded over by this committee of 18 politicians selected by the President of the Senate and the Speaker of the House of Representatives from the two political parties, who make "continuing studies" of the activities of the Commission, and under the Act of 1954 (section 202) it is the duty of the Commission to keep the committee "fully and currently informed with respect to all of the Commission's activities"—note the word "all"! The committee has in fact interpreted its mandate in such a wide way that it has participated in atomic energy decisions before, during and after they have been taken.

Mr. Palfrey also sets out the forces which led to the enactment of the Atomic Energy Act of 1954 which, with a few subsequent patches, such as the Anderson-Price legislation of 1957 (section 170), is the operative enactment now in force. The two Atomic Energy Acts of 1946 and 1954 (the latter "as amended through the year 1957") are printed in full in the second part of the book.

The three next succeeding articles deal with the activities of the individual state governments in the United States in atomic energy (which have just been enlarged by a new section (section 247) added last summer to the 1954 Act by Public Law 86-373), the problems of liability for atomic accidents and insurance against them, and the somewhat peculiar position about patents on inventions in the field of nuclear energy. Although these articles are written primarily from the American viewpoint, they touch on matters which are of great importance here. In this country, the Nuclear Installations (Licensing and Insurance) Act, 1959, passed last summer and which came into force on 1 April, has dealt with the major problems of third party liability by imposing an absolute duty on all reactor operators similar to the duty imposed on the Authority by section 5 (3) of the Atomic Energy Authority Act, 1954, and by requiring insurance cover or financial security to be provided for £5 million, neither more nor less, for each licensed site. On the continent of Europe there is much national legislation pending on the subject, as well as no less than three international conventions in draft; so that the whole question of liability is one on which authoritative information, such as that which Mr. Murphy's essay provides, meets an immediate need.

Mr. Blom-Cooper, of the English bar, has contributed an instructive and stimulating article on the law and administration of nuclear energy in this country, which although obviously of

Continued on next page

greater interest to foreigners will, when read with the preface to the United Kingdom legislation by Mr. R. A. Thompson, remind British readers of the legislative and administrative position as it was in the spring of 1958. As Mr. Marks says in his introduction, there is much food for thought in the contrast between the positions of the USA and the UK in the legislative field.

Three articles, each of the utmost importance, deal with the constitution and aims of Euratom, the European Nuclear Energy Agency of OEEC, and the International Atomic Energy Agency; they are written by lawyers who are directly concerned in these three organisations. M. Michel Gaudet's article on Euratom traces in a translucent style the ancestry of Euratom from the seed sown by Sir Winston Churchill at Zurich in the autumn of 1946, through the European Coal and Steel Community and the European Economic Community, the report of the "Three Wise Men" in May, 1957 (which recommended the installation of a nuclear capacity of 15 million kW by the end of 1967) and the Common Market. It provides in an easily assimilable form information on past disputes and compromises which materially assists in understanding the present hesitations and difficulties which Euratom is now exhibiting.

Similarly, M. Pierre Huet's article on the OEEC Agency is one which can be read with great profit. This Agency, in establishing a workable association of so many European nations to concert the exchange of information about their individual plans and to prepare the groundwork for international conventions on such subjects as health standards and third party liability and insurance, is playing a role of the greatest importance in the future history of modern Europe and no one interested in nuclear energy can afford to be ignorant of its nature and constitution, to which M. Huet himself has contributed so largely.

Mr. Max Isenbergh's essay on the Statute of the International Atomic Energy Agency is of great assistance in understanding the statute itself, which is printed in the second part of the book. The marks of distinction between the three international bodies, which (to the confusion of the neophyte) pursue similar objectives within three different but overlapping geographical areas, emerge clearly from these articles. The reading is often tough, but the result rewarding.

The remaining articles deal with bilateral international agreements for cooperation (there are some examples of such agreements printed at the end of the book) and the first Geneva Conference of the International Atomic Energy Agency. Lastly, there is a reprint of an address given by Mr. Phillip Sporn in May, 1958, at a meeting of engineers and architects at Haifa, which brings down to earth the economic factors among which nuclear energy will have to develop and expand.

The second half of the book is, in its way, even more stimulating than the first, for here, although the introductory notes prefacing the actual texts of the various acts, decrees and regulations, are in most cases an admirable guide through the text itself, the reader is left to draw his own conclusions. The different ways in which laws are promulgated in various countries and the literary styles adopted are most interesting. The tyro in the fascinating subject of comparative legislation will find a mass of material to work on.

It is perhaps a pity that the publication of this part was not deferred for a year or two, for it is only recently that legislators began to get down to the realities of nuclear energy and even yet there is not much legislation which gets beyond the stage of constituting atomic energy commissions and safeguarding the production of nuclear substances. But even though the legislation does not tend to be of any great intrinsic interest, there are certain aspects of it which call for comment. In the first place there was a high prestige placed on atomic energy in its early days. Commissions tend to be appointed by presidents and prime ministers; security requirements involve extraordinary privileges; mundane matters like revenue, and even income tax, are waived aside. Secondly, it is clearly easier for an individual sovereign state to legislate about a novel subject such as atomic energy than it is for a federal state. The United States surmounted the formidable hazard afforded by the absence of any reference to atomic energy in the Constitution by relying on the grounds of federal defence, but for other federations this assistance was not so readily available. In the United Kingdom we merely have adaptation clauses (where necessary) in our Acts of Parliament to apply the legislation to Scotland and Northern Ireland; but in Switzerland a plebiscite had to be held and no legislation had emerged by the time the book was printed. Thirdly, it seems that apart from Japan (whose laws fill 60 pages) and the United States, most countries were content to provide facilities for research without going into too much detail about the safeguards which have to be applied. So far as can be seen no other country had at the relevant time anything like section 5(3) of the Atomic Energy Authority Act 1954, which by-passed the principle of strict liability based on Rylands *v.* Fletcher and imposed absolute liability on the Authority in respect of hurt or damage resulting from radioactivity on their premises.

It is unfortunate that no contribution to the book has come from the USSR or China; it appears that efforts to obtain material from these and the other countries associated with them produced no response. The only peep we are permitted into a communist country is the Decree of the Federal Executive Council of Yugoslavia, signed by Josip Broz-Tito at Belgrade on 19 March, 1955, setting up the Federal Nuclear Power Committee and outlining its programme. The editors look forward to filling this gap in later volumes of the series, however, and it is to be hoped that the reception of the present work, which will fill a most useful place in the library of anyone interested in atomic energy and international cooperation, will stimulate the publishers to continue their efforts on behalf of their public.

C. J. HIGHTON

New Books

Locomotives I have Known. By J. N. MASKELYNE. *Percival Marshall.* (42*s*)

A collection of articles reprinted from *Model Engineer*, and covering 66 locomotives of the LB & SCR, L & SWR, SECR, GWR, LNWR, GNR, GER, MR, GCR, NER, MDR, NLR, CLR, L & YR, and CR. Mr. Maskelyne's personal reminiscences are an entertaining illumination of a useful and attractive source book.

Functions of a Complex Variable. By JAMES PIERPONT. *Dover Publications, New York; Constable, London.* (20*s*)

Originally published in 1914 and now reprinted in paperback form, this volume is notable for its full exposition of the theory of linear differential equations.

Proceedings of the 12th International Congress on Occupational Health, Helsinki, July 1957. *The Congress, Oy Pohjoismaiden Yhdyspankki, Helsinki, Finland.* (3,500 *FMks*)

A valuable collection of papers on many aspects of occupational health including noise, hygiene, human engineering, radiation hazards, the effects of shift working, and industrial nursing. The papers were given in English, French, German or Spanish, with resumés in English.

Lloyd's Register of Shipping Rules and Regulations for the Construction and Classification of Steel Ships, 1959. *Lloyd's Register of Shipping.* (42*s*)

Also published in a metric edition, in French, Spanish and German editions, and in sectional extracts. Rules for Steel Trawlers, and for Yachts (wood and composite, steel, and international rating classes) are also available.

The Measurement of Power Spectra from the Point of View of Communications Engineering. By R. B. BLACKMAN and J. W. TUKEY. *Dover Publications, New York; Constable, London.* (15*s*)

Previously published in the *Bell System Technical Journal*, this account is intended "for all who know *what* they want to accomplish by spectral measurement and analysis, though perhaps nothing of *how* to accomplish it."

British High-Speed Diesels. By C. MORGAN-JONES. *Temple Press.* (15*s*)

Engines of all classes up to 400 b.h.p., and used for automotive, marine, and industrial purposes, are covered. Maintenance, repair and running are clearly illustrated with diagrams and cutaway drawings.

Fringe Benefits. By FRANCIS M. WISTERT. *Reinhold, New York; Chapman and Hall, London.* (30*s*)

A survey of the history, cost and economic significance of fringe benefits, a term which the author points out is becoming very much of a misnomer as the benefits become more substantial and more essential to an accurate evaluation of wages and salaries.

The Reviewers

Mr. G. M. Warrington, B.Sc., is engaged in transmitting valve manufacture for the General Electric Company.

Mr. A. Binns, M.I.Mech.E., is manager of the Testing Machine Division of W. and T. Avery Limited, and is responsible for sales and design of their many testing and dynamic balancing machines. He maintains close connections with German associates and was a member of the British Intelligence Objectives Subcommittee machine tool and woodworking machinery investigation team in 1945.

Mr. C. J. Highton is principal legal and lands officer of the United Kingdom Atomic Energy Authority. He is a B.A.(Oxon) and a Barrister-at-Law (Inner Temple).

Trade Publications

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Electronics

Magnetic Amplifier. R. B. PULLIN & CO. LTD., Phoenix Works, Great West Road, Brentford, Middlesex. High gain magnetic amplifiers for use with servo motors. 400 c/s 115 V, primary output 18 W; ambient temperature range − 55° C to + 125° C. Leaflets.

Current Relays. ELCONTROL LTD., Wilbury Way, Hitchin, Herts. Overload and underload current relays, adjustable settings. Contacts rated 5 A at 250 V ac. High accuracy. Leaflet.

Construction

Dormitories. J. E. LESSER & SONS LTD., Green Lane, Hounslow, Middlesex. "Middlesex" prefabricated dormitories, based on four-man room. Complete with all plumbing, heating and wiring. Leaflet.

Formwork. KWIKFORM LTD., Waterloo Road, Birmingham 25. The Mark 2 type formwork has four basic components in steel to build any angular shape. Illustrated booklet.

Liner Plates. COMMERCIAL SHEARING AND STAMPING CO., Youngstown, Ohio, USA. Liner plates for tunnels and excavations. Thickness up to ½ in for tunnels up to 20 ft diameter. Booklet gives details and examples.

Building Service. HOLLOWAY BROTHERS (LONDON) LTD., West End Division, 43 South Audley Street, London, W1. Examples of contracts for houses, churches, sports pavilions, and boardrooms given in colour illustrated booklet.

Metal Windows. A. BEANES & CO. LTD., Bishops Bridge Road, London, W2. Window frames in bronze, aluminium and steel; painted or nylon coated. Modern and period designs shown in illustrated brochure.

Marketing

Display Problem for Vickers-Armstrong

How to display extruded, rolled and cast semi-manufactures to advantage on an exhibition stand? This was the problem confronting VICKERS-ARMSTRONG (ENGINEERS) Limited at the first Engineering, Materials and Design Exhibition, at Earl's Court.

Their solution was a 40 customer cross-section, including TECALEMIT, LEYLAND and AEI (MANCHESTER), showing a range of components and assemblies made from Vickers semi-manufactures.

The eventual stand, designed and built by LEON GOODMAN DISPLAYS Limited, gave a sound exposition of the varied uses and applications.

Sales Soar after Standardisation

A stimulating story comes from a Bristol firm who standardised not for one customer but for a whole market, the United States. The United Kingdom export of electric motors to the USA rose to about £1 million last year, from £157,000 the year before. The larger part of the increase was the work of Newman Industries of Yate, Bristol, who standardised their motors to the specifications of the American National Electrical Manufacturers' Association.

500,000 Homes a Year

One of the more influential of back-bench Conservative M.P.s' committees is that on housing. Its chairman, Mr. Graham Page, has come forward with a proposal that urban renewal and the provision of "additional new dwellings" should be at the rate of 500,000 new homes a year.

It is not easy to see where Mr. Page's amendment could lead. It is added to a Labour motion calling for greater Government encouragement to local authority building.

He asks the Government to remove planning restrictions on density, requisition and compensation. It would be idle to imagine that if density regulations were swept away the immediate danger of replacing old slums with new would not instantly arise. A great deal has been achieved by Mr. Henry Brooke, Minister of Housing, in de-requisitioning and compensation, such as it has been, is only tampered with at risk to the rights of the individual owner.

Motivational Researchers Please Note

The depth interview specialists may well study with interest the announcement by the MARKET RESEARCH SOCIETY that the use of hypnotism in market research has now been officially proscribed. The code of conduct is revised accordingly.

The Society makes it plain that it attaches importance to the fact that respondents in market research inquiries are volunteers. They have the right at any time to refuse to answer a question or even to go on with answering the questions at all.

The evidence examined leads the Society to believe that the respondent in a hypnotic interview may surrender conscious and critical control over what he is saying.

Husbands going into motor car showrooms now have official backing for saying to the salesman: "Don't look at me like that."

47,000 Letters on "Expanding Industry"

Some 47,000 managing directors of manufacturing firms, almost all those in the country employing more than 25 people, have received the pamphlet "Expanding Industry" and a letter from the Parliamentary Secretary at the Board of Trade, Mr. John Rodgers.

The letter was timed to arrive on these influential desks on the day that the Local Employment Act came into force, 1 April.

The powers the Government has taken to advance the cause of full employment in those areas, geographically remote or industrially tired, where the proportion of those without work is a problem have been widely publicised, but the pamphlet is a timely reminder.

As Mr. Rodgers points out in his letter, there is in the Development Districts listed plentiful labour and Industrial Development Certificates, which must be obtained for every new industrial building over 5,000 sq. ft, are readily granted.

The Board of Trade is able to provide factories either for rent or on deferred terms. One of the most useful of the Government's powers is related to the well-known problem that in these difficult districts the cost of putting up a factory may be more than it is worth on the market. In such cases the Board of Trade can make a grant of 85 per cent of this difference and in some cases this may amount to as much as a quarter of the cost of erecting the building.

Firms opening or developing in the special districts can also make use of Government loans, not only for capital equipment but for working capital as well. In some cases the initial interest can be remitted for the first year or two.

The "Expanding Industry" pamphlet lists 36 development districts in Wales, 74 in Scotland and 57 in England. Almost every town in Cornwall seems to have been included.

Since publication of the pamphlet nine further districts have been named. They are Plymouth, Gunnislake and Saltash, the Isle of Wight, Anstruther, and Dunfermline, Burntisland, Cowdenbeath and Inverkeithing.

BP Order Sulzer Design Diesel for New Tanker

The BRITISH PETROLEUM TANKER Company has decided on diesel machinery for its 35,000 ton tanker now building at the Hebburn shipyard of HAWTHORN LESLIE. The tanker should be complete early in 1962.

The engine is to be the most recent Sulzer design of single-acting two-stroke crosshead direct-reversing turbo-charged 8 R D 90 type developing 16,000 b.h.p. with a maximum service rating of 14,000 b.h.p. The largest bore supercharged engine to be ordered in Britain, the engine will be built by HAWTHORN LESLIE (ENGINEERS) Limited at St. Peter's Works, Newcastle on Tyne.

The new tanker will also have all superstructure abaft the cargo space. The changes, says BP, have been ordered to give experience of operation and maintenance of diesel engines of this size and of the ship handling characteristics of large tankers with the bridge towards the stern.

Politics and Business Policies

While the public and private budget debate rolls on, Lord Balfour of Inchrye has been delivering highly pertinent remarks to the 20th Congress of Commonwealth and Empire Chambers of Commerce, meeting in Canberra.

"The politician must realise that neither he nor his party nor any other party can create prosperity. All he can do is to create a climate for the conduct of successful commerce at home and overseas."

Thus said Lord Balfour, and it is plain from their agenda that the delegates to the Congress have many and strong ideas on how that climate should, or should not, be regulated.

The inaugural plenary session set up committees to deal with future economic policy, especially the General Agreement on Tariffs and Trade and Imperial Preference; problems arising from closer economic cooperation in Europe and elsewhere and development of the Commonwealth including communications and investment.

A lively awareness of the conditions affecting their affairs is shown in the list of subjects tabled for discussion by the member Chambers and Associations. They include the financing of developing countries; bureaucratic control; the need to investigate and minimise the effects of unfair trading practice with particular reference to Communist State trading agreements with Commonwealth and Empire countries, and the use of non-tariff devices for protective purposes.

Lord Balfour asserted that the old habit of businessmen claiming that they knew nothing of politics and had not time for "that sort of thing" was now dead. Every director of a commercial concern had to be close to the political picture of each country with whom his firm had any dealings.

Sales Tours and National Production

If the slight deterioration in the terms of trade, forecast as a possible by the Treasury's *Economic Survey 1960*, comes about then the need to increase the volume of United Kingdom exports in relation to imports will become even more urgent.

This achievement will only be possible, says the *Survey*, if home demand is not going to hold back exports, if prices are competitive and if British firms take full advantage of overseas favourable world conditions. The constant stream of managing directors, sales chiefs and chairmen setting off on sales tours and the activity of United Kingdom companies in foreign trade fairs indicates a high level of activity in this way.

As the recent Dollar Exports Council pamphlet on opportunities for British products in the Western states of the USA showed, there are still black spots where exporters are just not filling the shop windows to which publicity has drawn the overseas customers' attention.

On increased productivity the *Survey* is frankly pessimistic. Lacking the special conditions of 1959, the annual increase in national productivity of recent years of 2 per cent cannot be expected. With the immensely faster European advances and with the well known habit of the USSR to put 10 per cent on to its national product each year a decline in the UK's annual 2 per cent is not going to keep us our place in the world's markets, far less increase it.

It is to be hoped that industry's expected 14 per cent greater investment this year will make the Treasury's estimate as inaccurate as some of its revenue forecasts.

Japanese Competitor for Volkswagen

The NISSAN MOTOR Company, of Japan, is reported to have declared its intention to break into the European small car market.

The Bluebird car, manufactured by Nissan, may be seen in direct competition with the Volkswagen not only in the European market generally but in West Germany itself.

Two of "the largest ever" for New York

QVF Limited, chemical engineers in glass, of Fenton, Stoke-on-Trent, regard the British Trade Fair to be held in June in New York as an opportunity for increasing the sale of United Kingdom made chemical glass plant in the United States.

Mr. Brian H. Turpin, the QVF managing director, has explained that each item on the QVF exhibit will be from standard stock.

The company will be showing an all-glass condenser with an area of 60 sq. ft, the largest all glass condenser ever made, and the largest glass flask blown in the world, it has a capacity of 200 litres.

The QVF exhibit will also show an absorber (washtower), an 18 in column 40 ft high and a wide range of standard flasks and condensers.

£2 million Fixed Price Shipyard Orders

Two United Kingdom shipyards, CHARLES CONNELL of Scotstoun, and JOHN REDHEAD AND SONS, of South Shields, have won orders worth around £2 million, both at fixed prices.

Mr. G. H. R. Towers, chairman of John Redhead, said of the berth reservation by FRANK C. STRICK and Company for a cargo liner of 21,800 tons, that it was at a fixed price—"and a very hard fixed price at that."

Charles Connell will be building their eleventh of the 13 ships constructed since the war for the BEN LINE. She will be a fast diesel cargo-passenger liner of 13,250 tons.

The liner will be the first diesel-powered ship to enter Ben Line service. DAVID ROWAN, of Glasgow, will build the engine, a 10 cylinder SULZER turbo-charged diesel developing 13,500 b.h.p.

Series Motors in Domestic Appliances

Low weight and low cost are among the advantages of the series, or "universal," motor for use in household appliances. The characteristics for specific applications are reviewed.

By D. J. Pitstow, B.Sc. (Eng.), A.M.I.E.E.
Motor and Control Gear Division, Associated Electrical Industries Limited

The domestic appliance industry is one of the most buoyant in the country and this is reflected by the tremendous demand for electric motors. One of the chief types used is the series motor and this article is a review of some of their major applications in domestic appliances. Design trends are towards higher power-to-weight ratios and lower costs.

The main reason why the series motor is used so much is that it can be designed to run over a wide range of speed, unlike an induction motor which can only operate at a fixed speed depending upon the supply frequency. The maximum speed of an induction motor operating in this country (i.e. on 50 c/s) is about 2,850 r.p.m., while that of a series motor is governed by mechanical, rather than electrical, considerations and is often over 20,000 r.p.m. Since power is dependent on speed, by running the motor at high speeds it is possible to obtain higher power-to-weight ratio. This can be of paramount importance, since most domestic appliances are portable and often have to be held in the hand during use. Furthermore, the smallness of the motor also means that in large quantities it can be manufactured relatively cheaply and, although in many applications a gearbox is necessary to reduce the speed from the motor to the appliance, the overall cost is still economic.

ELECTRICAL CHARACTERISTICS

The general construction and principle of operation of the series a.c. motor is well known. It is similar to that of the d.c. motor with the field winding connected in series with the armature, so that the current and flux are always in phase. The characteristics of a typical motor are shown in Fig. 1 and the shape of the speed /torque curve is generally known as a "series" characteristic. This is recognised by the high torque at standstill and the high no-load speed relative to full load, very similar to that of a d.c. series motor.

Whereas, however, the d.c. motor characteristic is affected only by the resistance of the windings, the a.c. series motor is influenced by the reactance of the windings, particularly that of the field coils. At high speeds (when turns in the windings are low) this is of almost negligible importance, but when a motor is designed for low speeds, the field reactance absorbs a large part of the supply voltage. This results in a motor with a very poor speed regulation and a characteristic that is seriously affected by changes in supply volts. Thus, while with a high speed motor (say 10,000 r.p.m. on curve (*a*) in Fig. 1) a 5 per cent change in supply volts produces only a 5 per cent change in speed (at constant torque), with a motor designed for, say, 3,000 r.p.m. on curve (*b*) in Fig. 1, the corresponding change in speed would be about 15 per cent.

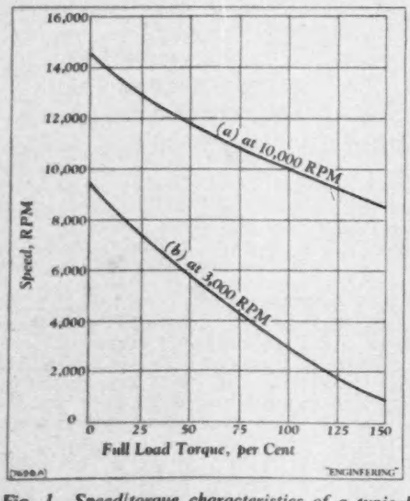


Fig. 1 Speed/torque characteristics of a typical series motor designed for a full load torque at (a) 10,000 r.p.m. (b) 3,000 r.p.m.

Though the speed of a series motor is not proportional to the supply frequency, it is still affected by it to a degree depending on the nominal speed of the motor. Thus, a high speed motor is less affected than a low speed one and it should be noted that an increase in frequency reduces the speed. While the reduction in speed of a motor designed for 10,000 r.p.m. due to a frequency increase of from 50 to 60 c/s is only about 5 per cent, the corresponding reduction for the same motor designed for a full load speed of 3,000 r.p.m. may be as high as 75 per cent.

The series motor will, of course, also operate on direct current and for this reason is often referred to as a universal motor. While this is a very convenient feature of the series motor, this fact alone is not nowadays important enough to influence the use of a series motor in place of an induction motor. At high speeds the d.c. and a.c. speeds for the same voltage are very similar, but at low speeds the speed on a.c. is appreciably lower than on d.c.

An approximate empirical formula for this relationship at the same voltage and torque is:—

$$\text{d.c. speed} = 2/3 \times \text{a.c. speed} + 3{,}000 \text{ r.p.m.}$$

MECHANICAL CONSTRUCTION

The mechanical construction of the series motor is very similar to that of a d.c. machine and usually has two poles (see Fig. 2, which shows possible shapes of the stator punching). Unlike some d.c. machines, however, the magnetic circuit is almost always laminated, but the armature and field windings are identical physically to those used on small d.c. machines. There is a growing tendency towards the use of moulded commutators, and on some motors satisfactory commutation is possible without undercutting the intersegment insulation.

While the conventional cartridge type of brush holder is perhaps the most common, there are many alternative designs involving pressed or cast components, with each design offering some special advantage in the particular application. Both ball and sleeve bearings are used in small universal motors according to the duty. The sleeve bearings are usually of the porous sintered type and are often self-aligning to take up any mis-alignment in the assembly of the motor. Thus machining operations on spigots, etc., are reduced to a minimum.

Although most universal motors are 2-pole machines, it is possible to vary the design of the stator lamination to allow a single field spool to be used, as shown in Fig. 2 (*c*). The design of the stator lamination usually governs the overall shape of the motor unit and in small appliances, such as those held in the hand, it is often convenient to use a special shape of punching, to make most effective use of the available space. For the same reason, some units incorporate faceplate type commutators so that the brush-holders do not protrude radially. It is usually necessary for the motor to be specially tailored to fit within an appliance.

Naturally, the universal motor suffers from some disadvantages but in most applications these are outweighed by the over-riding advantages of low weight and cost.

One of these problems is that of noise. Owing to the high speed of operation, a certain amount of noise from the brushes and ventilating fan is unavoidable, although it can be minimised by careful design. Another problem is that of brush life. With appliances subjected to a considerable amount of use, there is always the question of maintenance, which usually involves inspecting and possibly renewing the carbon brushes. The a.c. series motor is a machine inherently subject to a relatively high brush wear and the problem of commutation is the chief factor which prevents conventional series motors being built above the fractional horse-power range. It is possible to improve commutation by adding compensating windings but this so increases the cost that the main advantage of the motor is lost. Generally speaking, the difficulties of commutation increase with output power, speed and voltage.

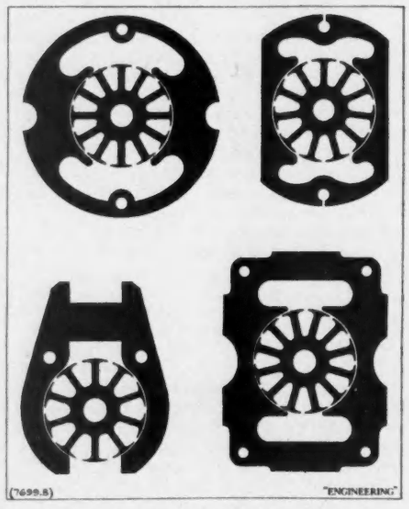


Fig. 2 Some typical series motor laminations.

Another of the important factors affecting brush life is the use of the correct grade of carbon brush. The carbon brush manufacturers offer a wide range of brush grades, which have been developed to meet the needs of varying types of motor, and it is often necessary to carry out protracted brush wear tests with many grades before the best is selected. It should also be stated that some grades are abrasive, and although offering reasonable brush life, quickly wear a groove on the commutator. It should be noted therefore that the brushes from a motor should not be replaced by others of a different grade.

Certain design measures are carried out to improve commutation and so increase brush life, but often these have a detrimental affect on the motor performance in other directions. One of the most common practices is to rock the brushes against rotation from the electrical neutral position. Very often this is achieved, not by physically altering the brushgear position, but by displacing the armature connections to the commutator. One affect of brush rocking is to reduce the motor efficiency, and also it will be observed that the motor immediately becomes non-reversible. Conversely, a universal motor which has to be reversible is bound to suffer as regards brush life. This latter problem has been overcome on some motors by mounting the brush-holders on a member which can be rotated

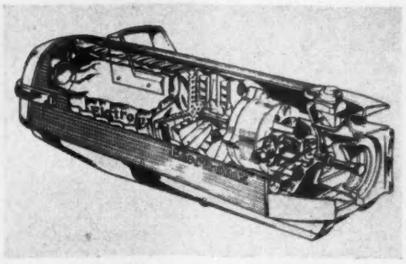


Fig. 3 Arrangement of a cylinder type vacuum cleaner. (Courtesy of Electrolux Limited)

so that, for each rotation of the armature, the brushes can be set in their correct position to give the required amount of brush rock. This, of course, entails added expense.

The a.c. series motor, like all commutator machines, is well-known as a source of radio and television interference. Today, it is usual for most domestic appliances to be fitted with suppressors to limit the interference to acceptable limits. Television interference suppressors are usually small and capable of being fitted inside the motor close to the source of interference, that is, at the brush boxes, but radio interference suppressors are usually more bulky and are best fitted by the appliance manufacturer external to the motor, at some convenient point in the wiring.

VACUUM CLEANERS

There are probably more vacuum cleaners than any other single type of domestic appliance in this country today and all these are powered by series motors. There are two main types of cleaner, each incorporating a different design of motor. They are the upright type and the cylinder type.

The upright type of cleaner incorporates a motor driving an impeller in an involute chamber, which sucks up air through the intake and discharges it into a bag. This air does not come into contact with the motor and a separate ventilation fan on the motor armature cools the windings. The motor is usually flange-mounted

Fig. 6 Sectional arrangement of a small hand drill. (Courtesy of Wolf Electric Tools Limited)

to a plate near the front of the cleaner or alternatively the drive endshield can constitute a member of the cleaner body.

The cylinder vacuum cleaner usually has the impeller system, motor and bag fitted in line inside the cylinder. The impeller system often comprises two or more stages of pressed aluminium impellers rotating within stationary air diffusers. The air passes axially through the impellers, along the cylinder, and either through or over the motor. Thus this type of cleaner relies on the created draught to cool the motor and it should be noted that if the inlet nozzle is sealed, only leakage air is available for cooling purposes. Fig. 3 shows a sectional arrangement of a typical cylinder type cleaner, and illustrates the method of mounting the motor.

It is not possible to generalise on the rating of vacuum cleaner motors owing to the wide range

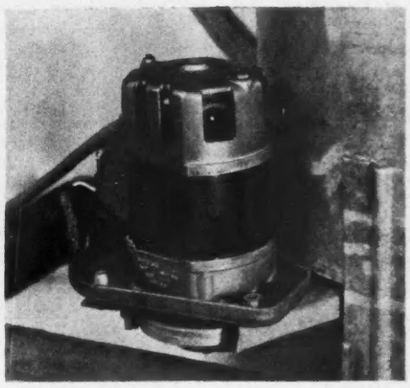


Fig. 4 Series motor mounted by endshield, driving spin dryer. (Courtesy of Wilkins and Mitchell Limited)

available. Small cleaners may be fitted with motors rated at less than $\frac{1}{8}$ h.p. operating at about 10,000 r.p.m., while some of the more powerful models operate at speeds of twice this figure and some are rated at over $\frac{1}{4}$ h.p.

SPIN DRYERS

The majority of spin dryers available in this country are powered by series motors; (Fig. 4). Although various methods of drive are used, the most common consists of a simple V-belt from the motor to the spinner spindle. A typical drum speed is around 2,400 r.p.m. driven by a motor rated at $\frac{1}{8}$ h.p. 9,000 r.p.m. These are typical figures but there are many spinners which rotate at higher and lower speeds.

Many spin dryers are designed to rinse as well as spin dry and in these cases a pump is required to remove the rinsing water. The pump may be driven by a separate motor, or more usually is belt driven from the main spindle, thus imposing further load on the spinner motor.

The motor must have sufficient torque available to accelerate the considerable mass of the cylinder and clothes up to speed in less than a minute, and appreciably more torque is required if the drum is badly out of balance due to the clothes being unevenly inserted. The main heating within the motor occurs during the acceleration period and a typical duty cycle consists of 4 minutes on followed by 2 minutes off.

A spin dryer is one of the few applications where the size and shape of the motor are not of prime importance. More vital in this application is a robust design to withstand the continuous vibration to which the whole appliance is subjected.

WASHING MACHINES

Although the majority of washing machines are powered by induction motors, a number of small models, usually with hand wringers, are driven by series motors. The motor drives the impeller through a belt reduction and offers an inexpensive and compact drive arrangement. A usual motor rating is $\frac{1}{8}$ h.p., 8,500 r.p.m. Fig. 5 shows a typical arrangement in which the motor is mounted vertically using tapped holes in the endshield of the motor.

PORTABLE TOOLS

Portable tools cover a wide range of appliances, of which very large numbers are nowadays manufactured. One of the most important is the small electric drill, which can be adapted to perform numerous other operations by fitting suitable attachments. Other portable tools include hedge trimmers, chain saws, electric hammers. Series motors are even used to drive lawn mowers. Most of these appliances are designed to be held in the hand, so that weight and safety precautions are probably the two greatest considerations. To minimise weight, high motor speeds are used in conjunction with a gear reduction to the drive. In many tools, space does not permit a separate motor to be fitted within the appliance casing and the casing therefore forms the end-shields and frame of the electrical unit. In these instances, the electrical manufacturer only supplies the stator and rotor unit and perhaps the brush gear. The power-to-weight ratio of these motors is high, and good ventilation is essential, so special attention has to be paid to the fan design and the air apertures in the tool. The rating of the motor naturally depends on the size of drill but a typical motor for a $\frac{1}{2}$ in drill would be rated at about $\frac{1}{8}$ h.p. at a nominal speed of 15,000 r.p.m.

Another consideration of this type of appliance is robustness. Tools are subject to very hard treatment, such as dropping on a concrete floor, and for this reason the use of a metal casing is desirable. This, however, aggravates the problem of safety, for it is highly desirable that in this

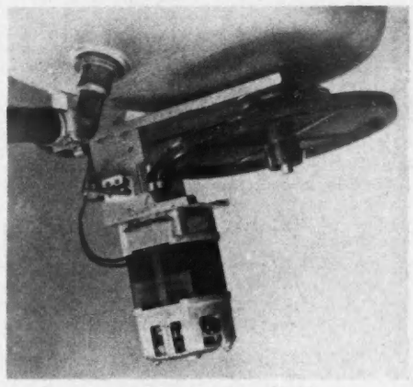


Fig. 5 Series motor driving impeller of small washing machine. (Courtesy of Vactric Manufacturing Limited)

type of application the motor should be " double insulated," that is, all metal parts of the motor should be insulated from the appliance casing, and that it should not be possible to touch any metal part of the motor unit from outside the appliance. This is one of the major design difficulties of this type of appliance and accounts for the introduction of plastic casings on some models. Fig. 6 is a photograph of a sectioned hand drill showing clearly how best use is made of the very limited space.

HAIR DRYERS

The motor rating required for a domestic

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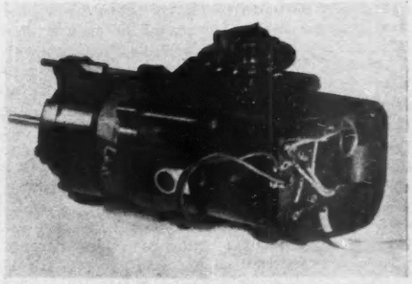


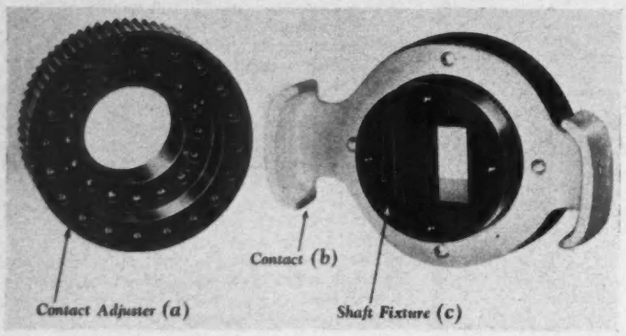
Fig. 7 A double insulated motor, with governor for a food mixer.

Electromechanical Switchgear Auxiliary

A new auxiliary switch of advanced design for linking mechanical movement with the associated electric control, protective and alarm circuits has been introduced by the General Electric Company Limited.

This switch, is of unit construction and composite assemblies for controlling up to 12 circuits can be built up. The contacts are silver plated, with a rating of 30A and suitable for breaking d.c. inductive currents of 18 and 25 amp at 240 and 110 volts respectively.

Adjustments can be made to the angular position of each moving contact relative to the operating shaft by means of a simple vernier adjusting mechanism which forms an integral part of each moving contact assembly. This arrangement enables individual contact assemblies to be preset in any one of 21 effective positions, for a shaft rotation of 90°, for timing the make and break of individual auxiliary circuits.



Contact assembly of the switch which will control up to 12 circuits.

Each contact assembly (illustrated) consists of three parts, the shaft fixture, the contacts, and the contact adjuster. The shaft fixture (*c*) and the contact (*b*) each have four equally-spaced detents which engage respectively with an inner and outer circle of indents in the knurled contact adjuster (*a*). The inner circle has 16 indents evenly spaced 22½° apart, and the outer circle 20 indents evenly spaced 18° apart.

By moving the contact adjuster and contact together one position, the contact is turned through 22½° relative to the shaft fixture. Securing the adjuster and rotating the contacts back one notch (that is, 18°) results in a net change of 4½° in contact position relative to the operating shaft.

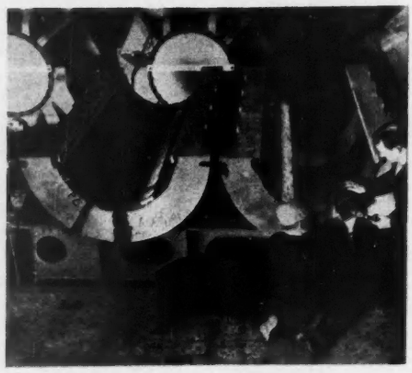
A spring is provided to prevent the contacts. moving out of engagement involuntarily during adjustment, and a clamping screw at the end of the shaft firmly locks the moving contacts.

Tufnol Bearings for use at Sea

Tufnol laminated plastics is very much in evidence on the Canberra, the new 45,000 ton P and O passenger liner under construction by Harland and Wolff Ltd. The 42 ton rudder is hung in bearings made from strips of this material and designed to permit generous lubrication by the sea-water in which the bearings are immersed. Tufnol is used also outboard for the intermediate steady bearings that support the propeller shafts. These bearings, shown in the illustration, are segmental and are machined to size from special mouldings. Many other parts of the same material provide electrical insulation in much of the equipment used on the Canberra.

This modern material has many advantages that commend it for this service, including long life, resistance to corrosion, small dimensional change, very low water absorption, consistent quality without faults or distortion, easy machinability and availability in strip, sheet or tube to suit exact requirements. Furthermore, it may be stored indefinitely without the need for special precautions.

Sven Salen, San Conrado and Bulima are but three of the many recently launched ships that have bearings of Tufnol.



Concluding **Series Motors in Domestic Applications**

hair dryer is usually about $\frac{1}{40}$ h.p., and a compact motor unit is possible with a speed not exceeding about 6,000 r.p.m. Too high a speed is undesirable from the point of view of noise and vibration. For these reasons, there has been a trend over the past few years to use shaded-pole motors running at about 2,000 r.p.m., with the fan redesigned to give the same airflow while running at the lower speed.

SPEED CONTROL

One of the advantages of a series motor is the fact that its speed can be altered electrically. It is possible to do this in three different ways, although each has its limitations:—

(*a*) Control by addition of series resistance.
(*b*) Control by variable governor.
(*c*) Control by tapped field winding.

The first method is probably the cheapest, but it should be noted that speed control by this means is only satisfactory when the load imposes a constant torque. For example, if a motor were running at about half speed (so that half the applied voltage appeared across the motor and the remainder across the resistance) and the torque was then doubled, the current would also nearly double, the volt drop across the resistance would rise almost to the value of the supply volts and the motor would stall. This difficulty can be overcome by manually varying the resistance to suit the load, as in the case of sewing-machine motors.

The other two methods do not suffer in this respect and are sometimes used in domestic food mixers.

SEWING MACHINES

Most hand-operated sewing machines can be converted for electric operation by fitting a small motor. Although in some machines the motors are fitted underneath, the majority of motors are mounted on the side of the machine, using a special bracket engaging in a recess in the motor endshield. The motor is usually rated at about $\frac{1}{16}$ h.p., 3,500 r.p.m., and speed control is obtained by inserting resistance in series with the motor. This is achieved by a foot controller which either inserts resistance in a series of steps or comprises a slider operating over a wire-wound resistance, offering a smoother control.

An attractive external finish to match the sewing machine is required, without holes large enough for finger entry.

FOOD MIXERS

Owing to the variety of attachments which can be fitted to modern domestic food mixers, it is essential for the motor speed to be varied to suit each particular operation. Since the torque often varies considerably during the operating cycle and it is not practicable to expect an operator to adjust a controller in a similar manner to a sewing machine, speed control by the insertion of series resistance is obviously not suitable for food mixers.

One of the best solutions is the use of a variable-speed governor. A conventional type of small governor is mounted on the motor shaft and through linkage operates a switch in the motor circuit. Thus the motor is constantly being switched on and off. The governor can further be designed to permit the motor to run at a number of different speeds by adding a manual control, which varies the governor setting. The advantage of this type of control is that the speed remains constant for all values of torque up to a given overload value.

In order to ensure smooth operation and to prevent undue arcing at the contacts, a resistance is permanently connected across the contacts so that, even when they are open, a small current flows through the motor. The governor creates severe radio and TV interference and extra components are required to afford suppression. A typical rating for such a motor is $\frac{1}{4}$ h.p. at 9,000 r.p.m. A double insulated motor with the governor is shown in Fig. 7.

Other food mixers use a motor with tapped field windings and with this arrangement a number of tappings are brought out from the field coils to a selector switch. This method is only suitable for light loads and for applications where a lower torque is required at the higher speeds. If a heavy overload torque is encountered under a weak field condition, a heavy current will be drawn and overheating of the motor is likely. Under this condition commutation and brush life is often poor and severe radio and TV interference may be caused.

ACKNOWLEDGEMENTS

In conclusion the author wishes to thank the many electric motor and appliance manufacturers who have cooperated in the preparation of this article and also the management of the Motor and Control Gear Division of Associated Electrical Industries Limited for permission to publish it.

Ablation Cooling for Missile Re-entry

Ablating materials offer protection from heat to probes and satellites entering planetary atmospheres. Teflon is very suitable, but more efficient ablators are required.

THE PLACING of Pioneer V in orbit between Venus and the earth indicates that very soon efforts will be made to hit Venus with a probe. Experience gained in radio communication with Pioneer V will be invaluable when telemetry equipment has to be designed for such an experiment, but experience gained in designing ICBM nose cones has also an important contribution to make. An instrument package entering the atmosphere of Venus with a velocity of about 40,000 ft per sec and near normal incidence may undergo a peak deceleration of up to 400 *g* and a peak heat transfer rate of over 7,000 Btu per sq. ft per sec (over 50 kW per sq. in). To protect the instruments some form of ablation material will be required, such as that used for protecting missile nose cones.

In the process of ablation, heat is absorbed by melting—possibly followed by vaporisation—or by direct sublimation of material. A summary of the fluid mechanics of ablation was recently given by Professor L. Lees, California Institute of Technology, in a paper " Ablation in Hypersonic Flows " (read at the 7th Anglo-American Aeronautical Conference, New York). A diagram of the zones appearing during melting ablation is reproduced on this page.

HEAT MECHANISM

At hypersonic speeds the hot gas in the " shock layer " between the body and the bow shock wave becomes partly or fully dissociated. When this mixture of atoms and molecules enters the boundary layer, strong concentration gradients are produced and heat energy is transported towards the surface, partly by diffusion and partly by ordinary heat conduction. Recombination reactions occur in the boundary layer and some of the gas components may react chemically with vaporising surface material. In detail the reactions are extremely complicated; but the convective heat transfer rate at the gas-liquid or gas-solid interface depends primarily on the total enthalpy difference across the gas boundary layer, provided the ratio of mass diffusivity to thermal diffusivity of the gas is nearly unity.

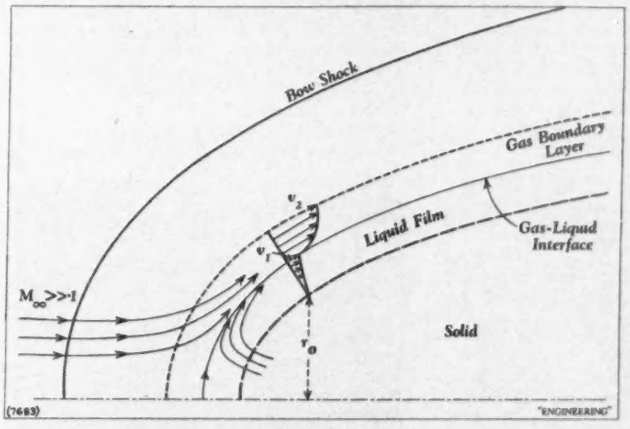
At hypersonic speeds heat energy is also transported to the body surface by radiation from the hot gas in the shock layer. For most entry trajectories the gas radiative heat transfer rate is much smaller than the convective transfer rate. But for direct entry into a planetary atmosphere at near normal incidence gas radiation may dominate. Radiation from the shock layer to the body occurs mostly in the ultra-violet or near infra-red protion of the spectrum, while radiation from the much cooler gas-liquid or gas-solid interface occurs mostly in the infra-red to far infra-red. Thus the gas in the shock layer is nearly transparent to infra-red radiation, and this mode of heat transfer is important for ablators required for the Venus probe.

The most important physical property of a melting ablator is the viscosity of the liquid film. The larger the viscosity the greater the film thickness. This in turn increases the temperature rise across the film and the amount of heat absorbed by the ablator. As long as vaporisation does not occur, the gas boundary is virtually independent of the presence of the liquid film.

At the forward stagnation point, the temperature rise is completely independent of the body nose radius, unless the gas boundary layer is turbulent, in which case it depends slightly on body dimensions. The enthalpy increase across the liquid film is much smaller than the enthalpy difference across the gas boundary layer, because the thermal conductivity of the liquid is so much larger than that of the gas and their thicknesses are of the same order of magnitude. Nevertheless, at hypersonic flight velocities of the order of 18,000 ft per sec the additional energy absorbed by the countercurrent flow of liquid across this film amounts to about 70 per cent of the heat capacity up to melting for a laminar gas boundary layer, and to about 100 per cent for a turbulent gas boundary layer.

For a typical melting ablator, the total heat capacity is about 1,200 Btu per lb for laminar gas flow and about 1,500 Btu per lb for turbulent gas flow. The restrictions on maximum heat transfer rate imposed by a non-melting solid heat sink are removed and the effective heat absorbing capacity is comparable with that of a high temperature metallic heat shield.

When vaporisation occurs at the gas-liquid interface, or when sublimation takes place directly from the solid phase, the counter current of gas away from the surface makes up a large fraction of the enthalpy difference across the gas boundary layer. A substantial increase in the effective heat capacity of the material is obtained by means of the blocking effect of mass addition on heat transfer at the interface. In fact, the effective ablation heat capacity increases almost linearly with the external stagnation enthalpy, and can reach values of 5,000 Btu per lb for laminar flow and 2,500 Btu per lb for turbulent flow at flight speeds of 20,000 ft per sec.



Schematic diagram of a two-phase boundary layer over a melting blunt nosed body at high velocity.

DATA FROM ICE

Ablation experiments are carried out with high temperature equipment such as arcs or plasma jets. For certain purposes such measurements are sufficient, but study of the fluid mechanics of ablation calls for work under more carefully controlled conditions. One way of doing this is to use ice in hypersonic wind tunnels, operating at stagnation temperatures of about 400° C.

At sufficiently low local static pressures ice sublimes, and the heat of ablation becomes about 1,000 Btu per lb. And it has been found that ablation measurements on ice can be regarded as a convenient base-line for evaluating experimental techniques. Measurement of the ablation rates and surface temperatures on a water-ice hemisphere cylinder model at the stagnation point and also on the cylindrical afterbody showed encouraging agreement between laminar theory and experiment.

Because of the comparatively low heat transfer rates obtained on models in a moderate-temperature hypersonic tunnel the ablation process is stretched out in time, and studies of transient effects can be made—determination of the time taken to reach steady-state ablation, for example. Another question suitable for investigation on the longer time scale is the feed-back mechanism between changes in body shape brought about by ablation and the distribution of static pressure and heat transfer rates around the body surface. For example, one would expect that a hemispherical nose would become flatter with time until the heat transfer rate reached near uniformity across the face. On the other hand along the cylindrical afterbody the pressure is nearly independent of local body shape, and—according to blast wave theory—decays inversely with distance from the nose. By rough calculation, therefore, the equilibrium afterbody shape is a paraboloid on, provided the nose is quite blunt.

DESIGNING ABLATORS

Because of the high stagnation enthalpies associated with the entry of satellites or probes into a planetary atmosphere, the effective heat of ablation should be large. But the requirements imposed on ablating materials for this application are quite different to those of ballistic missile re-entry. For example, when re-entry is initiated from a circular satellite orbit, the entry angle is likely to be very low—less than 2°. This is because of the prohibitively large retro-rocket weight required for a steeper descent. The maximum convective heat transfer rates for a typical non-lifting vehicle under such conditions are about 65 Btu per sq. ft per sec, or less than one-tenth of the values encountered by a ballistic missile. And the duration of the heat pulse is about 250 sec, or ten times longer. For such conditions a low temperature, low density ablator with a low thermal conductivity is required. The same physical properties are needed to minimise the problem of heat conduction to the interior during the long soak times.

Teflon meets these requirements to a remarkable degree. But there is a strong incentive to develop materials that ablate at even lower temperatures than Teflon. When lift is employed, for example, the duration of the heat pulse increases roughly as the lift-drag ratio, for a given shallow re-entry angle, and more insulation and a greater weight of ablator are required.

The situation is quite different for entry from highly elliptic orbits or for the approach of a probe to a planet. In these trajectories, a steeper entry angle is an important method of alleviating the difficult guidance and control problem associated with grazing entry and multiple-pass drag braking. Because of the relatively high convective heat transfer rates and the high stagnation enthalpy along the trajectory, a gaseous ablator would need an effective heat capacity of at least 6,000 Btu per lb. Again the comparatively long duration of the heat pulse dictates a low or moderate temperature, low density ablating material, and a poor thermal conductor.

Improved Engine Laboratory Facilities

As a first stage in the expansion of their engine development facilities, Vauxhall Motors Limited have recently opened a new laboratory block. It is equipped with some novel and interesting apparatus.

VAUXHALL MOTORS Limited have recently completed the first constructional stage of a new laboratory block at their Luton factory. Three laboratories, each containing a powerful electrical dynamometer, are now in operation and a fourth is being equipped for use in the next few months. The building also contains a laboratory for development work on carburettors and diesel fuel-injection systems.

This new building and its equipment form part of an expansion and modernisation scheme for the Luton works engine testing and development facilities which previously included nine dynamometers, all housed in the main engineering building which was constructed in 1937. When completed it is envisaged that the new building will accommodate 16 dynamometers of various types for testing petrol and diesel engines, a vehicle dynamometer, a vehicle cold room and a fuel-injection laboratory.

The dynamometers now being used are the latest d.c. electrical type, produced in America by General Electric. Such a dynamometer, which is basically a shunt wound motor/generator, has in the last few years come to be recognised as the most versatile and suitable machine for all forms of automobile engine test work. When being driven by an engine, the torque delivered to the armature of the dynamometer is transmitted to its carcase by magnetic flux. Since the carcase is mounted on trunnion bearings and is therefore free to rotate, it is a relatively simple matter of mechanical coupling to measure the torque developed by the engine.

The three 150 h.p. sets of d.c. electrical dynamometer already installed are of a type which has for some time been a speciality of the General Electric Company, Schenectady, USA; the fourth, a 200 h.p. dynamometer which is to be put into operation soon, has been made by Heenan and Froude Limited, Worcester.

These machines incorporate a number of electrical and mechanical design features which are conducive to accuracy, ease of control and reliability. Outstanding among these are the oil-floated trunnion bearings, remote torque-indicating mechanism and the provision for carcase mounted accessories. In the case of the GE dynamometers the speed and the torque/speed relationship can be controlled automatically with great precision by means of an electronic Ward-Leonard system; such an arrangement permits the use of compact controls and therefore simplifies the test routine. Provision is to be made for supplementing the Ward-Leonard system used with the Heenan and Froude machine with further electronic control.

The control panels, which stand adjacent to each dynamometer (see Fig. 1), have been ergonomically designed and are capable of controlling both engine and dynamometer with exceptional ease and precision. The dynamometer electrical controls are small and are located in a group on a horizontal sub-panel; to the right of this are the throttle and ignition controls and the ignition switch. At the rear of the sub-panel are the revolution counter, r.p.m. indicator, elapsed time indicator, inlet and outlet engine coolant temperature indicators, engine oil pressure gauge and oil temperature indicator. The vertical portion of the panel contains the torque load indicator, oil and automatic pressure controllers, a 12 point thermocouple temperature indicator, four manometers and an electric clock. There are also numerous other controls and signal lamps related to the engine under test, the operation of the dynamometer and its auxiliary gear, and various other ancillary equipment in the laboratory.

In addition to the several engine performance laboratories, a small section of the new building is set aside for development work on carburettors and diesel engine fuel-injection systems. The main equipment used for carburettor test work is known as a flow test bench (see Fig. 2). This apparatus was redesigned by Vauxhall engineers from an original specification by General Motors (Vauxhall's parent company). It consists essentially of a vacuum pump; air, fuel flow and vacuum measuring instruments, fuel supply and a sealed chamber in which the carburettor under test is installed. Air can only enter the sealed chamber by passing through the flow measurement device. In operation the vacuum pump draws air through the carburettor while replacement air is drawn through the flow meter. Fuel is introduced into the carburettor through a conventional fuel connection but only after it too has passed through a metering device. Thus both air and fuel are metered at the same time.

The sealed chamber, the calibrated orifices (right foreground), the controls, and the instruments can be seen clearly in Fig. 2. The sealed chamber, which is on the left of the picture, takes the form of a deep hood capable of being raised or lowered (hydraulically) for the installation and removal of the test carburettor. The sides of the hood are glazed for observation purposes and its lower edge is sealed in a mercury bath in order to exclude air when tests are being made.

The main function of the flow bench is to obtain air-fuel mixture ratios by direct readings of mass air and fuel flows, taken while simulating the whole range of carburettor inlet depressions and throttle settings obtained when the carburettor is fulfilling its normal function. While the flow bench does not exactly reproduce all engine operating conditions for the carburettor under test, it goes a long way toward facilitating the checking, and comparing the effects, of carburettor modifications. With the experience that has been gained so far in correlating flow bench test results and tests carried out under real automobile conditions, this equipment makes an important contribution to carburettor development work.

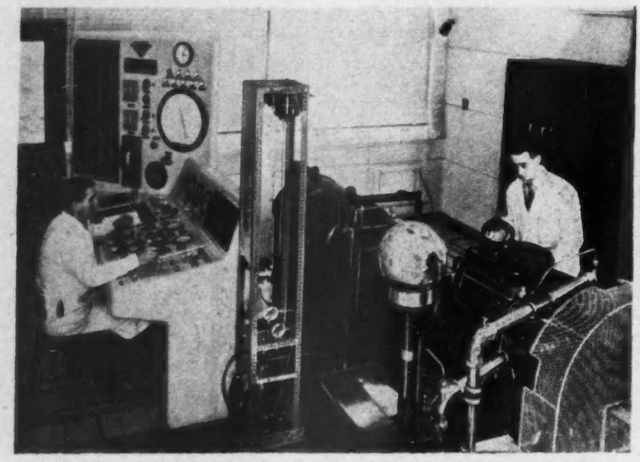


Fig. 1 The dynamometer laboratories are neatly arranged in clean surroundings. In the illustration the dynamometer can be seen in the middle, the control panel on the left and the engine under test on the right.

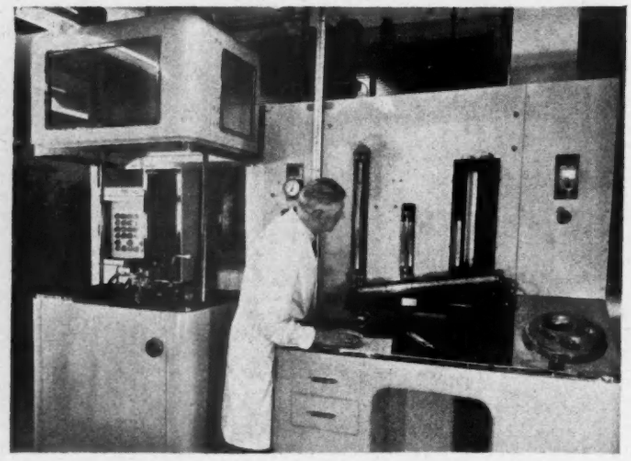


Fig. 2 An elaborate apparatus, designed and built at the Luton works, is used to obtain information about the dynamic characteristics of carburettors.

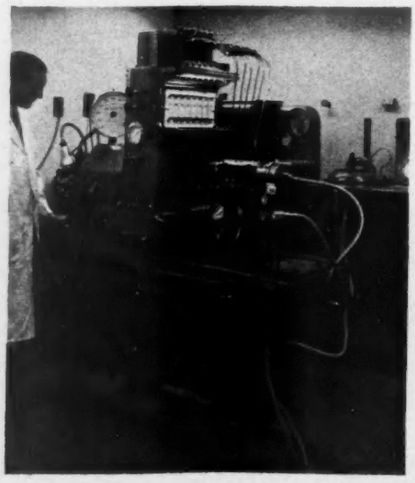


Fig. 3 In the fuel-injection test room, apparatus is available to measure the flow and injection characteristics of diesel engine fuel systems.

Self-Powered Wheel for Cross-Country Work

Cross-country motor vehicles, particularly the more rugged ones, may well be changed in concept by a recent development in power transmission. A "self-powered wheel" has been demonstrated by the Locomotive and Car Equipment Division of General Electric in the United States; it is completely self-contained and requires no external mechanical connections. It could be particularly useful in opencast mining, road construction and many other projects where the terrain is rough.

The motorised wheel, as it is called, makes possible a 125 ton haulage vehicle with the manoeuvrability of one weighing only 40 tons. In appearance, it is dwarfed by its huge 10 ft diameter tubeless tyre, looking like a giant tractor wheel. The power unit, an electrical traction motor, together with the transmission system, is in the hub. Current for the motors of a vehicle using motorised wheels would be supplied by cable from a diesel-driven generator. Each wheel can develop 380 h.p. at the rim, giving a total of 1,520 h.p. for a vehicle using four of these wheels.

In the event of the motorised wheels on one side of a vehicle losing traction in mud or snow, the amount of current supplied to those wheels would be reduced. At the same time, provided they had a good purchase, the current to the other wheels would be automatically increased.

Another inherent advantage of the motorised wheel is the powerful braking system that it provides. Travelling at top speed, which would be about 30 m.p.h., a motorised wheel can bring itself to a complete stop in a distance of only three times its circumference. This can be accomplished without strain on the brakes because on deceleration the motors act as generators powered by the forward momentum of the vehicle. Under this condition the electric power developed by the driven motors is dissipated as heat in a resistor network. This dynamic braking system acts on the same principle as the braking systems used on many diesel electric and electric railway locomotives.

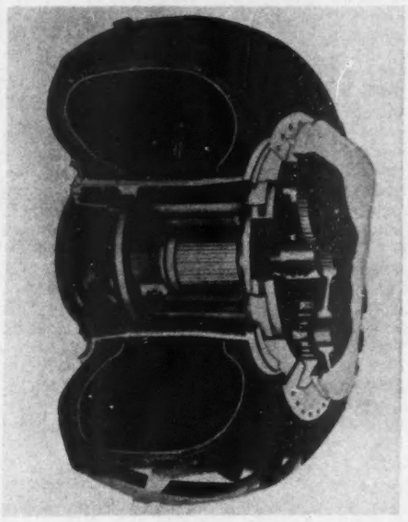
A motorised wheel requires no normal transmissions, axles or differentials, since each wheel contains its own power producing element. The fact that there are fewer working parts also reveals two other advantages: lower maintenance costs and more maintenance-free working days; and higher fuel efficiency, due to the lack of transmission parts. According to the manufacturers of the motorised wheel, its other major advantages are these:

(1) It can use full engine horsepower rating over the entire speed range. This means that from low speed to top speed the maximum pulling capacity can be applied to the load.

(2) It will not stall if it meets a momentary excess load. The maximum available tractive effort is two or three times the rated tractive effort and can be maintained for a full minute without damage to the driving mechanism.

(3) It can be operated at higher speeds more safely, because of the positive control that ensues from superior braking.

(4) It can climb gradients of 10 per cent or more under full load faster than conventional vehicles of equivalent horsepower. (Vehicles are proposed for 15 per cent gradients at speeds in excess of 10 m.p.h. with full loads.)



A heavy-duty motorised wheel has been developed by General Electric in the USA. Its electric traction motor is included as an integral part of the wheel.

Transistor Circuit for Engine Ignition

Transistors have been used experimentally in engine ignition circuits by the Electric Autolite Company, Toledo, Ohio. They reduce wear at ignition points and offer the possibility of an ignition system with no current-interrupting contacts at all. In the present circuit (Fig. 1) the transistor amplifies the current through the ignition points about 30 times before passing it to the primary of the ignition coil. This means that instead of having to make and break about 7·5A, the contacts only have to deal with 0·25A. Consequently they suffer much less damage from arcing.

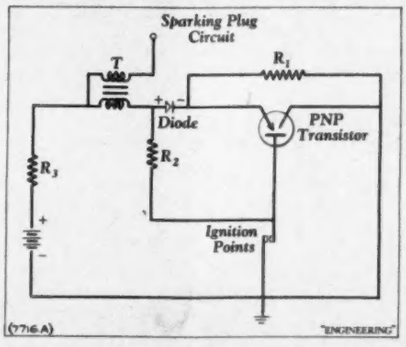


Fig. 1 (left) By use of a transistor, the current through the ignition points is reduced by about 30 times. This greatly decreases contact wear.

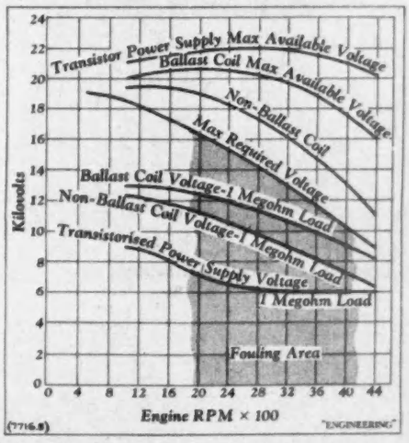
Fig. 2 (right) The voltage characteristics of the transistor system. In the fouling region the increased temperature of deposits results in reduced resistance across the sparking plug.

The transistor unit is more complicated than the coil and condenser it replaces, and is more expensive. It should, however, be useful where reliability and longevity are principal considerations. It produces an almost constant voltage throughout the engine speed range and is relatively insensitive to battery voltage fluctuations. Further development of the unit is likely to overcome the growing problem of fouled sparking plugs. The present programme of research is described in a paper "Transistor Switched Ignition Systems," by G. E. Spaulding, Jr., which was read at the annual meeting of the Society of Automotive Engineers, Detroit.

A PNP germanium transistor is used because of its cheapness in comparison with high-current silicon transistors. Until NPN transistors are available in greater quantity the unit is restricted to use with engine casings at a negative potential. The circuit uses the transistor's ability to amplify current. When the ignition points close, a small current flowing through the emitter-base circuit will switch on the transistor and permit a large current to flow through the emitter-collector circuit. With the development of more sensitive transistors it may be possible to dispense with the use of mechanical contacts and rely on a signal current produced, for example, electromagnetically.

The diode provides a means of reverse biasing the emitter-to-base junction when the points are open. This ensures transistor cut-off even at high temperatures. Resistor R_1 allows a small current to flow through the diode continuously, producing a 0·5 to 0·75V drop across it, which effectively biases the transistor. This action is enhanced by keeping R_2 at a low value; but R_2 cannot be reduced beyond a value that limits the current through it to a reasonable amount when the points close. A heat sink on the transistor enables it to operate in ambient temperatures of 180° F. The traditional condenser across the points has been eliminated.

The voltage characteristics of the transistor circuit are shown in Fig. 2, in comparison with other types. Autolite claim that under conditions of plug fouling its performance is at least equal to that of a conventional coil system. By appropriate changes in circuit parameters the voltage ceiling can be lifted to provide for future engine changes. The company's present programme includes the development of a high-voltage auxiliary-gap system and a low-voltage condenser-discharge surface-gap system. Both offer reliable operation where fouling of the surface and points of the sparking plug by lead or carbon is a problem.



Armchair Communications

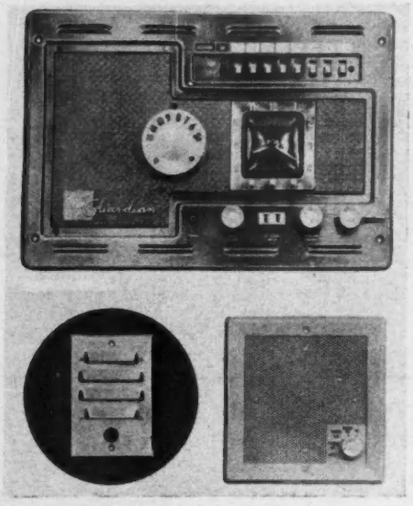
THERE is a fascination in being able to speak from one room of a house to another. Almost every boy's hobby book contains the instructions for making an indoor telephone, usually consisting of a wire tightly stretched between two tins. It required much skill and patience to make it work. There must have been quite a number of radio enthusiasts, too, who have rigged up a microphone in one room and linked it to the speaker in the set.

A really elaborate system for internal communication is the American Webster Guardian. It allows for a master set and up to eight remote stations spread round the house, indoors and out. The simplest of the versions has for its master an amplitude modulated radio set which will relay to all or any of the eight remote stations either the radio programme or, by turning the switch to "talk," any message from the main room. The remote indoor stations have a selector switch allowing them to receive the radio programme, receive messages, and transmit messages to the master set speaker. Alternatively, the switches can be set so that any message from a remote station can be superimposed on the radio programme being played on the master set—quite a useful arrangement for baby sitters. The intercommunications amplifier is sensitive enough to transmit the normal speech of persons who may be up to 30 ft from the station.

The three other models in the system offer increasing facilities. For instance, the next more elaborate includes separate volume controls for radio and intercom operation and provision for a record player. Another incorporates a clock that can be set to switch the radio on and off automatically ("wake up and be put to sleep to music"), sound an alarm at any pre-set time, and time electric appliances. The fourth set is an AM FM receiver with all the facilities of the other sets (but without the clock) and, in addition, contains an arrangement that will answer the door and one for speaking from one remote station direct to another.

One of the troubles of a large block of flats served by a common door and hallway is that both must normally be open and are a possible entry for undesirable prowlers. The Ateavox automatic door porter has been designed to overcome this trouble by an arrangement of grouped bell pushes on the outer door, a telephone system from each flat to a speaker/microphone at the door, and a lock on the outer door controlled electrically from within each flat. The lock is a spring one so that the door is caught again as soon as it closes.

At some suitable position in each flat the Novophone instrument is mounted. It consists of a standard hand set with a wall support and a push button that controls the door lock. At the door is the bell push panel and above it the combined loudspeaker/microphone unit protected against the weather. The speaker unit can also be installed with existing bell systems as a flush mounting set. The installation has the obvious advantage that it saves frequent trips up and down stairs to open the outer door, while at the same time giving the security of a closed entrance. Flats with the equipment do not also need a hall porter, which can be an economy in running costs. A large number of these sets is being installed in new premises and have been approved by insurance companies. They are normally supplied on a rental basis which includes installation and maintenance.



(Above) The Guardian system has a master radio set with intercommunication facilities to outdoor (left) and indoor (right) remote stations.

(Left) If television circuits are used, a single nurse can watch over several babies in different rooms, or even in different flats.

A grander and more costly system for baby sitters was shown at the recent Ideal Home Exhibition at Olympia. Whereas the Guardian system, like the home-made microphone pick-up, only allows the sounds of the infant to be monitored, this system caters for remote viewing. In other words it consists of a series of closed television circuits with cameras mounted one to each child, relaying their pictures to screens in the living room or the nurse's sitting room. Thus from her seat the nurse can not only hear when one of her charges is in distress but can also see what the trouble is. Only a low level of lighting is needed to supply the cameras so the baby is not blinded by glare. The system is obviously suitable for large blocks of flats where one nurse can watch over several infants. It is reported as being in use in California but so far it does not seem to have been arranged to superimpose on the broadcast television programmes, as the Guardian system does on sound radio, although such an arrangement is probably possible.

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Notes for the guidance of contributors are available from the Editor. Contributed articles usually carry the author's name when published; they should be exclusive to ENGINEERING. When an article is accepted for publication the author is normally advised of the planned publication date.

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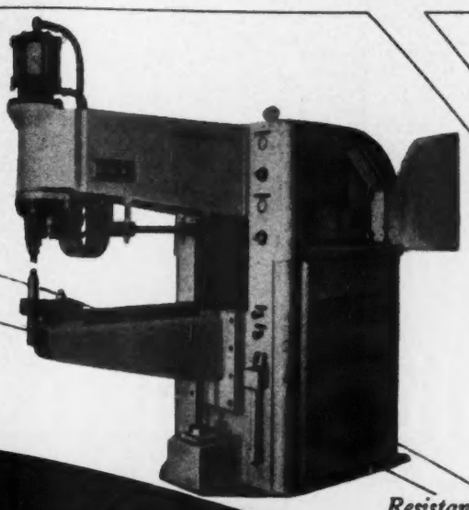

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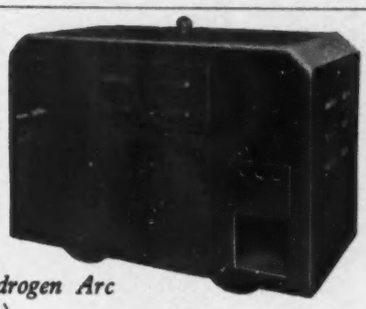

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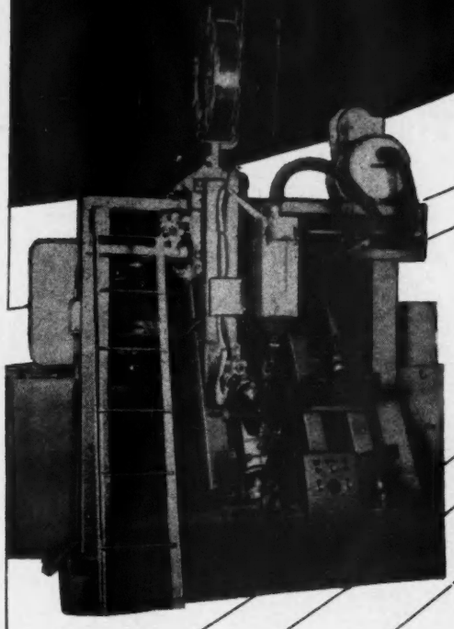

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Behind the range of AEI electric welding equipment is the research and experience of a vast engineering organisation making extensive use of this equipment in its own factories.

You have the benefit of all this when you buy welding equipment from AEI. *For further particulars write to your local AEI office, or direct to—*

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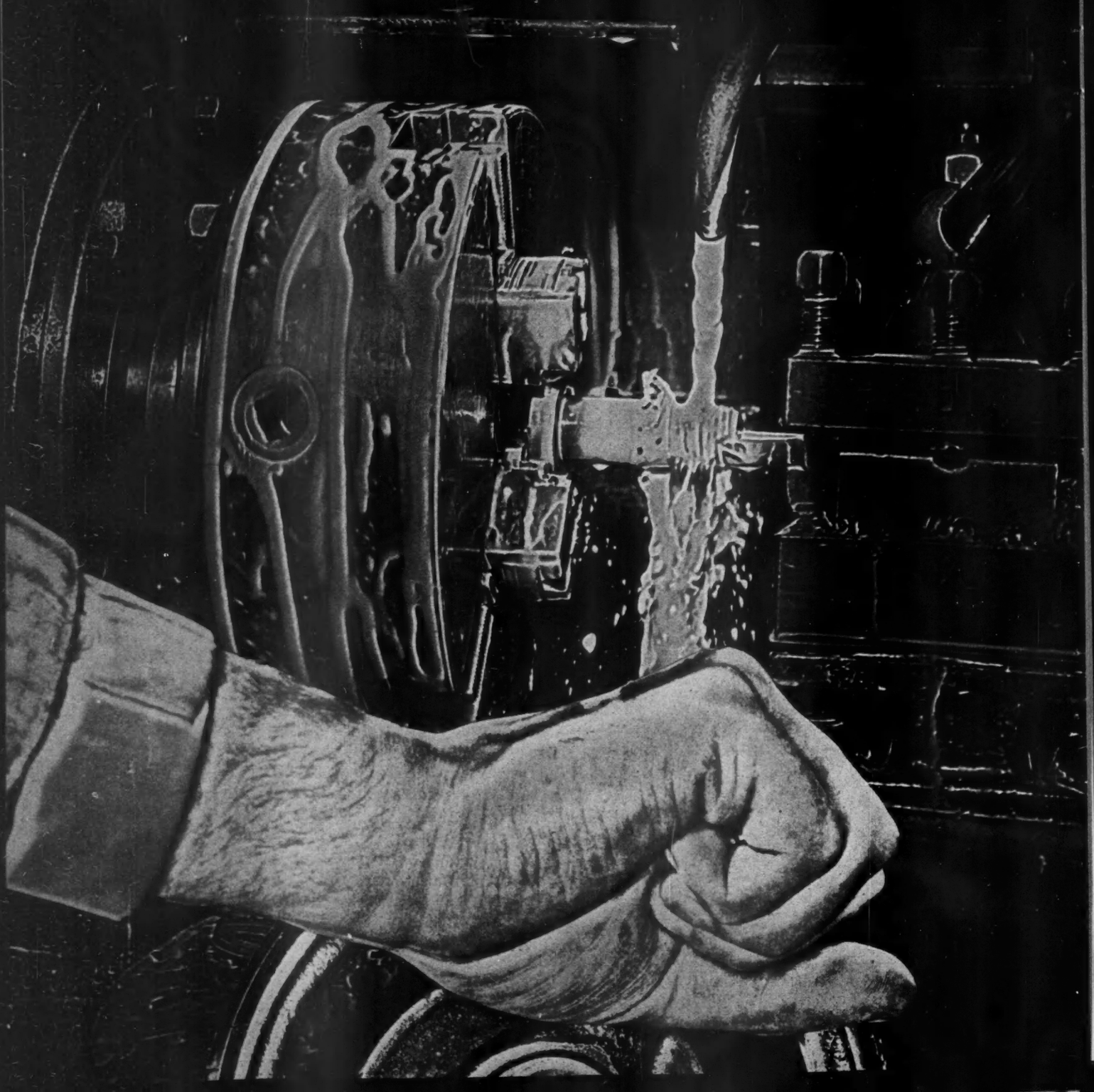


With new Shell Dromus Oils

Most modern soluble cutting oils contain phenolic compounds used as coupling agents between the oil and the emulsifier, for better blending and easier mixing. These phenolic compounds can cause skin irritation, especially where modern high-speed machines are used and the emulsion can concentrate, through the evaporation of water, above the safety level.

Shell research chemists have been working on this problem, which has been causing some concern to Management. After considerable research, Shell Dromus Oils have been reformulated and these new cutting oils now produce bland emulsions, which considerably reduce the risk of skin trouble to operators.

The real difficulty was to find a new coupling agent to replace the phenolic compounds, and Shell finally used what their chemists know as a higher fatty alcohol complex. This solved one problem, but presented another. The new coupling agent was volatile at the high temperatures normally used in blending processes. Further research found a solution to this problem by designing and installing new plant. The new Dromus Oils are every bit as efficient as before and cost no more. They put Management in the welcome position of being able to minimise working hazards at no extra cost. And machine men need no longer be so worried about skin troubles.

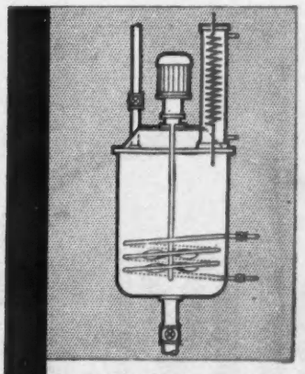
The moral of the story is that Shell research is supremely applicational. The centre at Thornton is always ready to work with even the most specialised sectors of industry to produce the right oil for the job. If you and your organisation have any major lubricating problems, it pays to get in touch with your local supplier of Shell Industrial Lubricants.

The Research Story

Shell chemists in the U.K., in Holland and in the U.S.A., prepared and examined hundreds of experimental soluble oils, and established that certain combinations of fatty alcohols could be used in place of phenolic compounds with no loss of efficiency. They set to work to discover the best combination and developed a higher fatty alcohol complex which fitted exactly. Then they realised that to blend this new coupling agent into soluble oils would require special plant and new blending techniques.

Exhaustive testing of blend stability, emulsion stability, anti-corrosion and machining properties led to selection of the most promising blends. A pilot plant was set up to produce batches of these for use in field trials.

This field testing and final development proceeded for two years whilst production plants were erected at points so chosen as to give the most economical and rapid delivery throughout the United Kingdom.



This is the blending kettle. The reflux condenser beside the stirrer motor prevents the loss of constituents volatile at the blending temperature.

NEW SHELL DROMUS SOLUBLE CUTTING OILS

another proof of Shell leadership in lubrication

PHOTOGRAPH BY COURTESY OF THE ENGLISH ELECTRIC CO. LTD.

100 ton ROYCE CRANE. 85 feet span. Auxiliary hoist 25 tons. Creep speed provided on all motions. Two motor main travel drive without cross shaft. Fully articulated end carriages.

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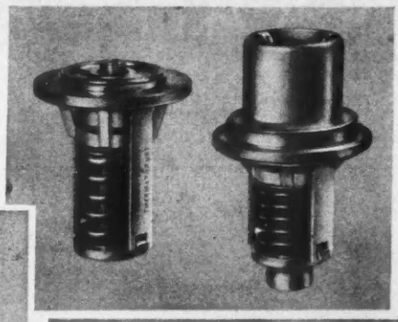

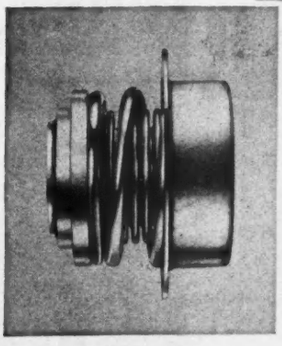

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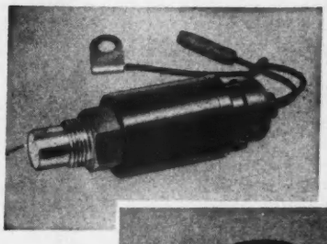
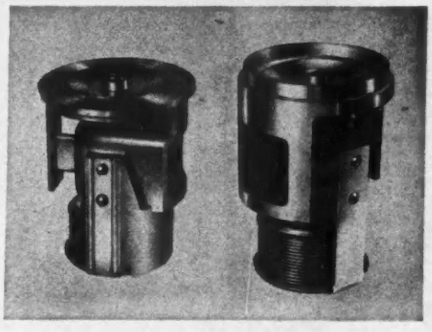
HEAVY DUTY TEMPERATURE AND PRESSURE SWITCHES





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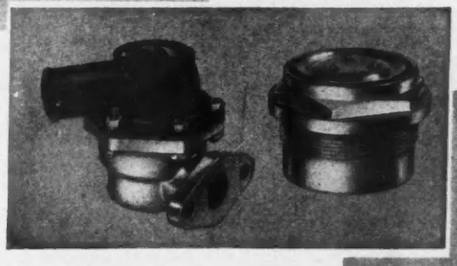

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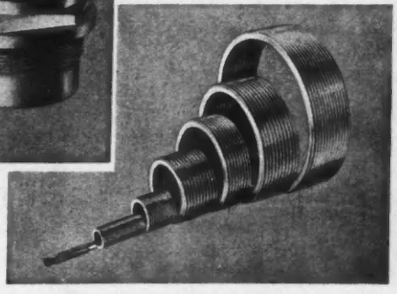

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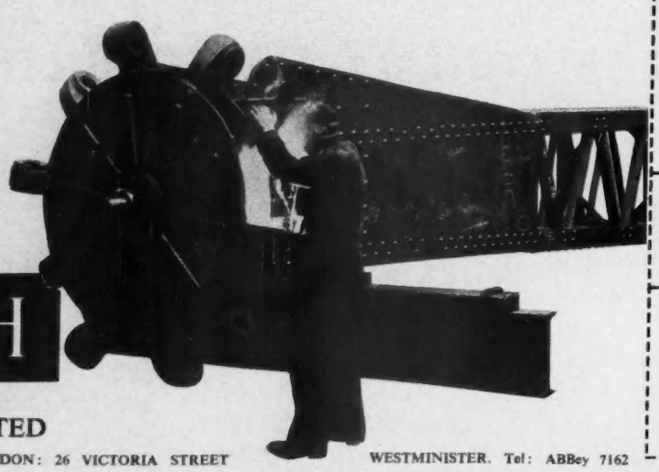
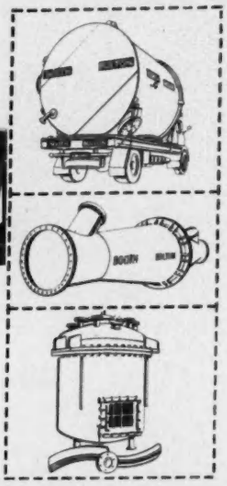
The photograph shows one of our welders at work on the all-welded crown plate for a 150ft. guyed derrick. Our greatly enlarged and improved welding facilities are at your disposal for the fabrication of all sizes of storage tanks, pressure vessels, and welding work to your own requirements





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Supplied with 14 t.p.i. general-purpose blade and 225/250 v. motor unless otherwise specified. All models immediately available. Write for fully-illustrated folder BS-10 to:

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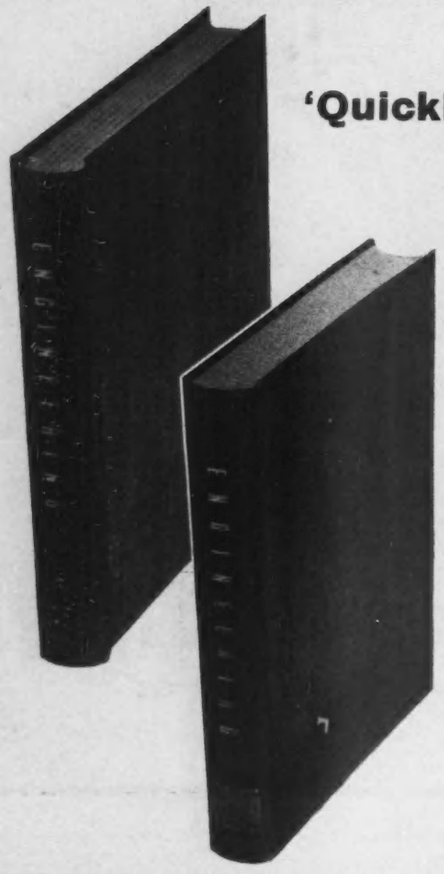

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This bank was designed to receive billets from the hot shear run-out table of the Billet Mill, transfer them singly whilst cooling and marshall them for off-loading when cool. By this method the billets are not deformed during handling. It is suitable for billets of 4″ square by 18′ 0″ in length. The length of travel being 85′ 0″ at a maximum speed of 20′ 0″ per minute.

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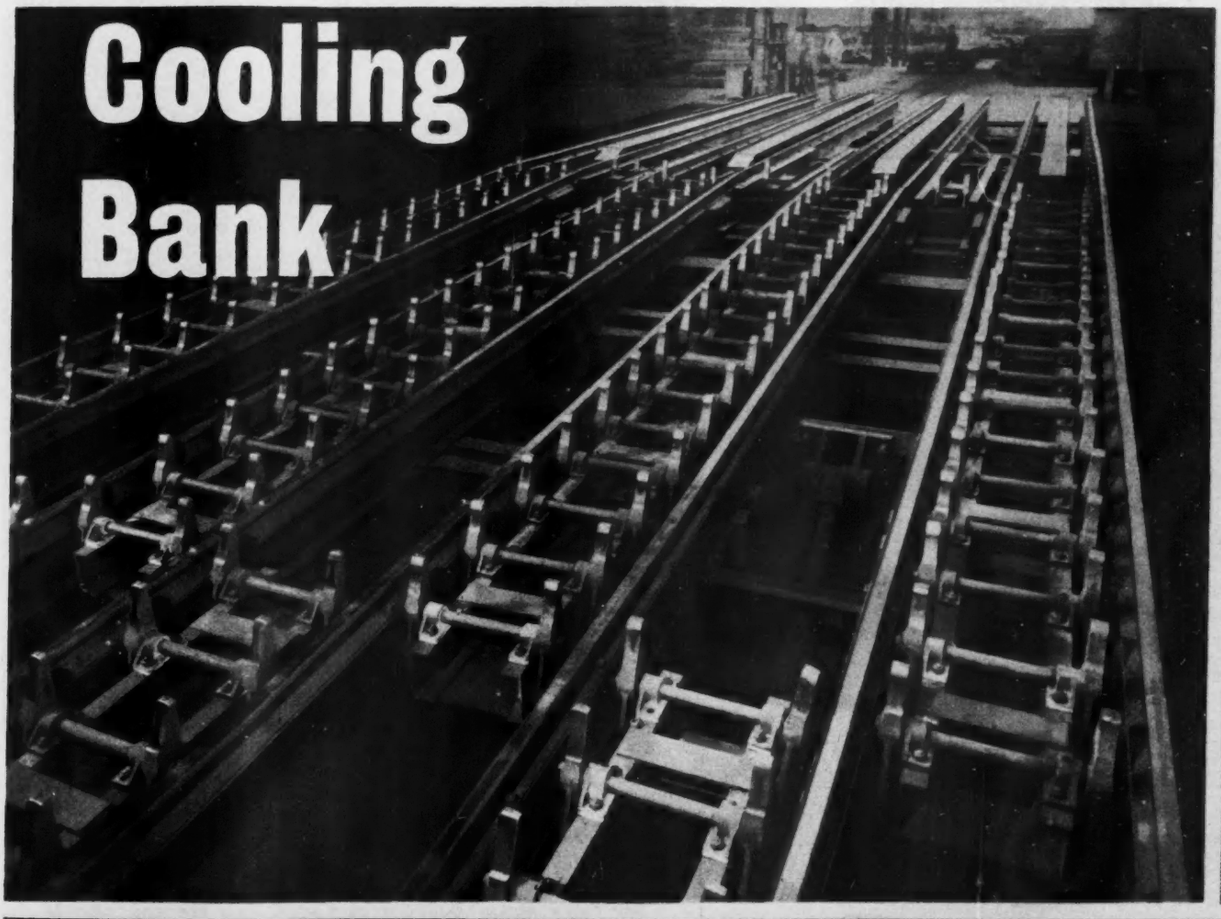

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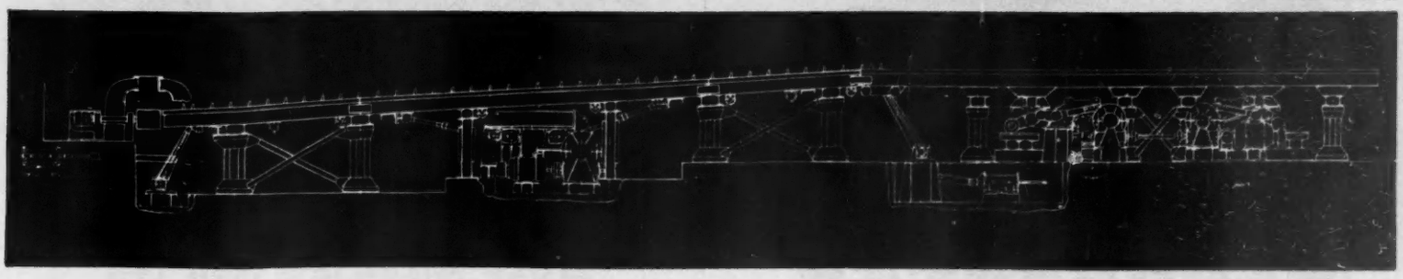

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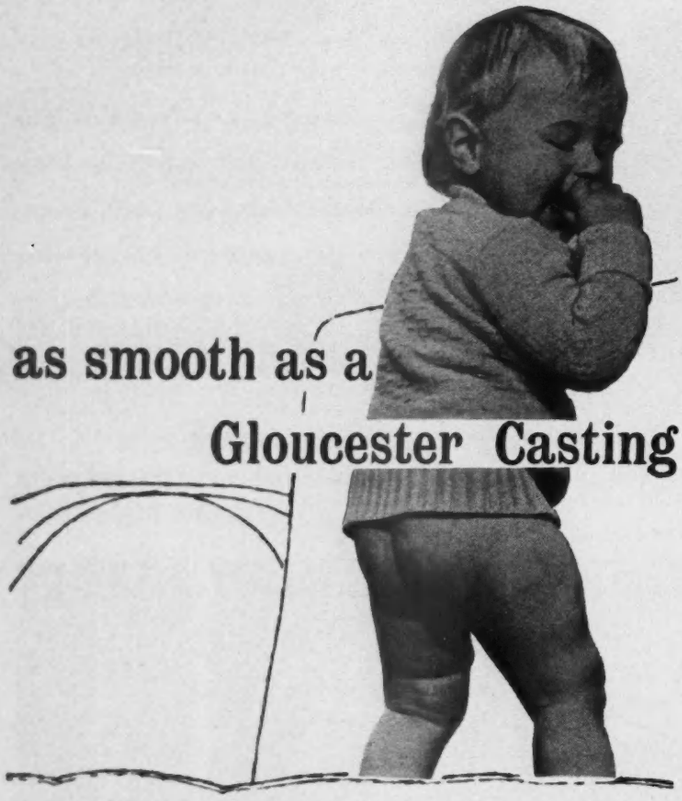

as smooth as a Gloucester Casting

The smoother and cleaner the casting the more accurately it fits into the machining jigs allowing saving of time during machining process. At Gloucester, Malleable iron castings are as clean as modern science and machines can make them.

Superb core making equipment, careful analysis of sand at every stage of the core making and moulding processes, the use of special mould and core dressings, ensure clean castings, even as they leave the " knock out " bay for final fettling.

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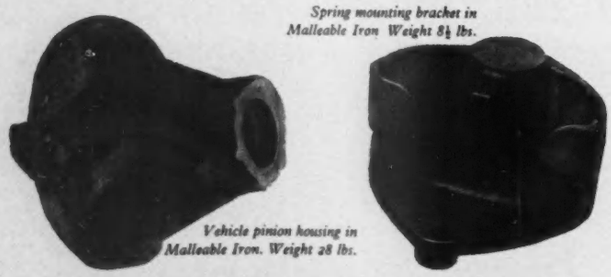
Gloucester can handle large runs of malleable castings for the automobile, railway, electrical and farming industries.

Gloucester are always willing to visit customers and help in the design of castings to save time and cost in production.

A typical Gloucester Malleable specification.

Gloucester Blackheart Malleable		*Gloucester Lamellar Pearlitic Malleable*	
Elongation	18%	Elongation	5%
Yield Point	12 tons	Yield Point	24 tons
Tensile Strength	25 tons psi	Tensile Strength	35 tons psi

Spring mounting bracket in Malleable Iron Weight 8½ lbs.



Vehicle pinion housing in Malleable Iron. Weight 28 lbs.

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THE HOME OF GOOD CASTINGS

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Rockwell designed, Cockburn engineered—a combination that provides valves superior to any on the European market. Cockburn-Rockwell Butterfly valves ensure precise throttling and positive shut-off regardless of the pressure, temperature and nature of the fluid or gas. Direct or remote control can be provided with manual, pneumatic, hydraulic or electric operators. Cockburn-Rockwell valves are made in all standard sizes up to 132" in any metal; they can be rubber lined to resist corrosion or stress-sealed for extreme temperature variations.

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REGENT REGAL HYDRAULIC OILS

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5 special features make Regent Regal (R & O) Oils invaluable for all hydraulic operations

INCREASING USE IN BRITISH INDUSTRY

To operate efficiently, even the simplest hydraulic system must be kept absolutely clean. This means that wear must be reduced, rust eliminated and gum and sludge deposits prevented.
Regal Oil (R & O) does all this, and gives long-lasting protection to all industrial hydraulic systems.
Which is why more and more British industries are turning to Regal Oils (R & O) for high quality performance and complete dependability.

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Regal Oils (R & O) contain powerful oxidation inhibitors which minimise the possibility of gum or sludge deposits and increase intervals between drain periods.

PREVENT RUST

Regal Oils (R & O) contain a rust inhibitor which 'plates out' on metal surfaces, forming a tenacious film that is impervious to rusting action of moisture and water. This eliminates the damage so often caused by rust.

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Regal Oils (R & O) cling to metal surfaces and penetrate between closely fitted bearing surfaces, giving adequate lubrication. This way wear is minimised.

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Regal Oils (R & O) are processed so that they are highly resistant to foaming. This characteristic is improved by additive treatment.

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Regal Oils (R & O) are manufactured in different viscosity grades to meet every operating condition and give excellent performance at both high and low temperatures.
Regent Regal Oils (R & O) meet the requirements of the British Hydraulic Pump Manufacturers. The range comprises:
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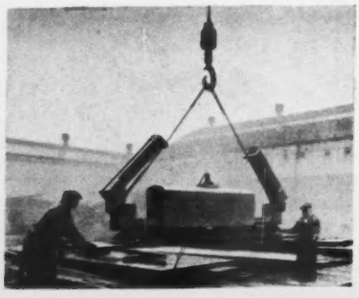
LIGHTWEIGHT PORTABLE VACUUM CLAMPING AND PLATE FAIRING MACHINE, TYPE 2.
Designed to facilitate the assembly of the component parts for welded fabrications.

ALL WELDED FRAME
30 feet high and 25 tons in weight.

DIESEL ENGINE BEDPLATE AND FRAMES
Another example of Pickering Welding Craftsmanship.

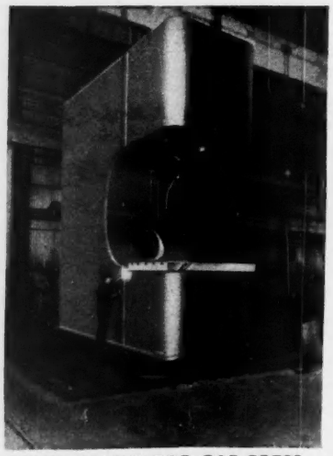
VACUUM CLAMPING UNIT
For the rapid Assembly of Fabricated Parts.



VACUUM LIFTING UNIT
For handling plates of varying lengths in lifts up to 6 tons.

the **TOOLS** *for the job*

and the **JOB** *itself*



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ORIENT & PACIFIC LINES

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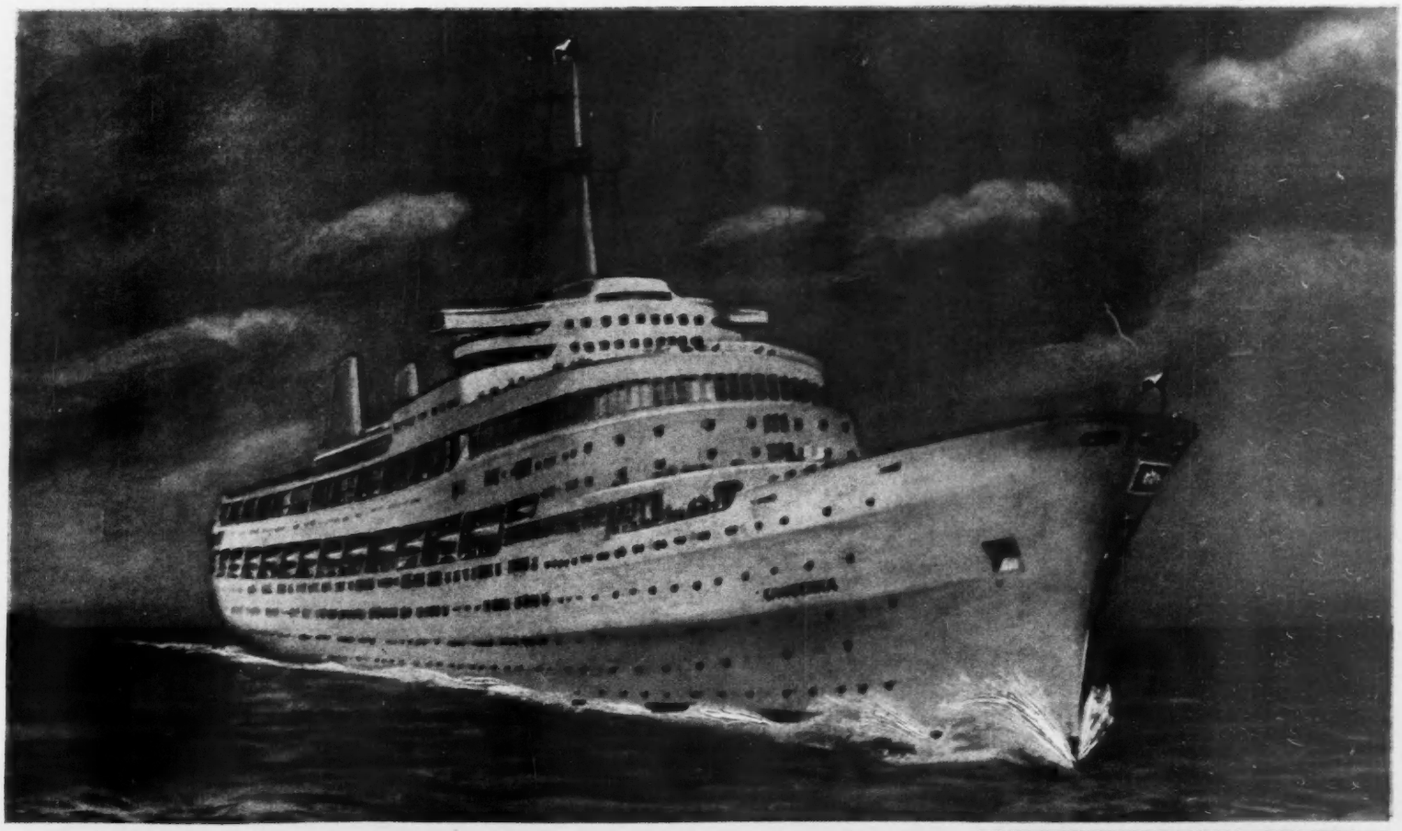
BEING BUILT BY HARLAND & WOLFF, BELFAST.

This is another of the world's famous ships in the construction of which BEARDMORE will play an important part.

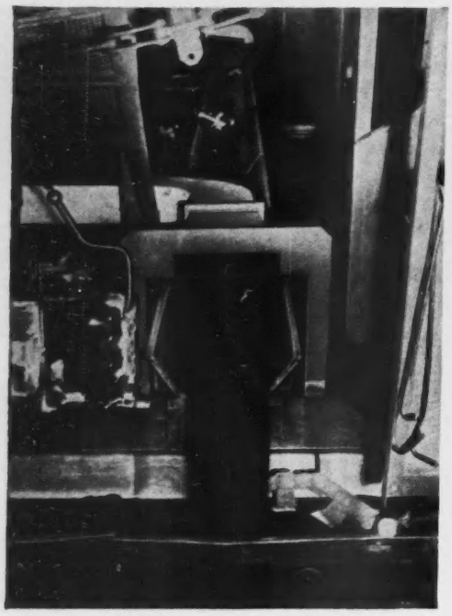
BEARDMORE castings and forgings include:

To Harland & Wolff, Belfast
Rough Machined Forged Steel Propeller Shafts, Tube Shafts, Intermediate Shafts, Thrust Shafts.

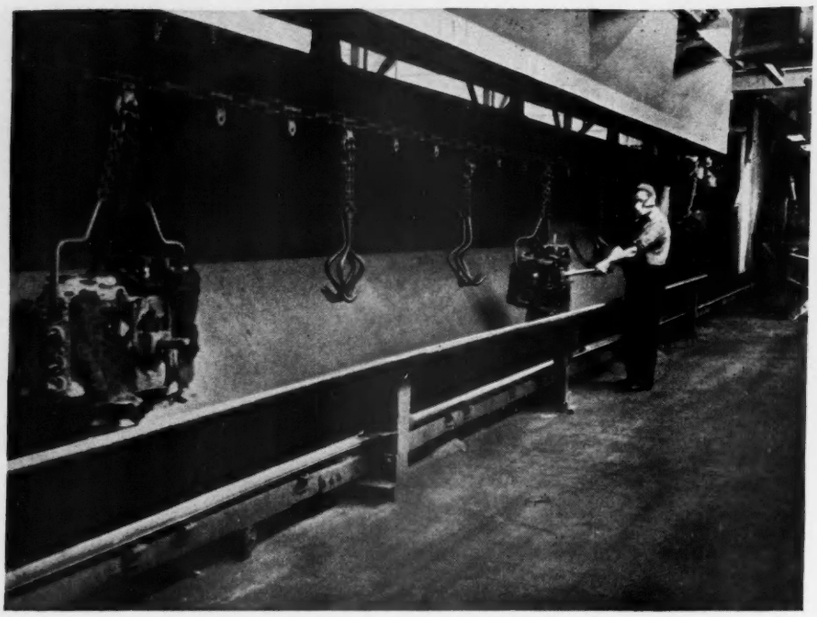
To Brown Brothers, Edinburgh
Castings and Forgings for Stabiliser Fins and Fin Shafts, Forged Steel Tiller Crosshead.



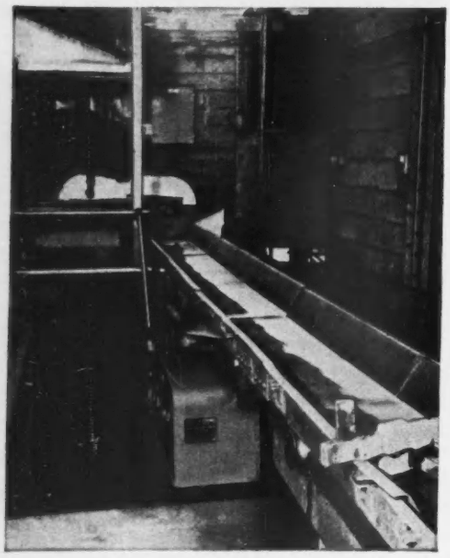
Forgings and Castings to the largest dimensions in Carbon and Alloy steels, including Boiler Drums, Forged Steel Fully Hardened Work Rolls, Forged Steel Solid and Composite Back-up Rolls, Heavy General Engineering Plant and complete machining facilities.



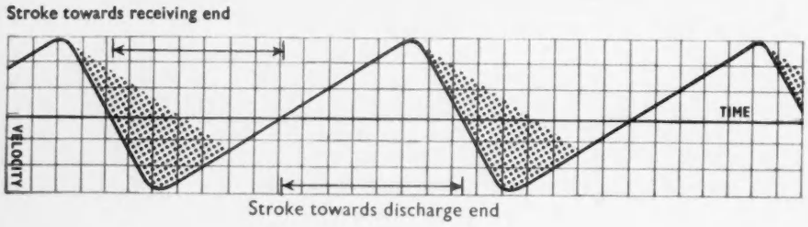
Shaker conveyor discharging scrap on to a similar conveyor. (The photographs reproduced in this advertisement are published by courtesy of Ford Motor Company Limited.)



Sand cores and risers from engine component castings fall on to a shaker conveyor which carries them to a rotary scrap breaker and sand separator.



Shaker conveyor showing type G20 drive, driven by a 20 h.p. flywheel motor: this robust drive delivers high peaks of energy.



SHAKER CONVEYING

in a mechanised foundry

The Distington-Goodman shaker conveyor is not a jigger conveyor. Its troughs move in only one plane on ball-bearing rollers and propel material by variations in their rates of acceleration and deceleration (these are shown in the time-velocity curve above: the shaded areas represent the movement of material independent from the movement of the troughs).

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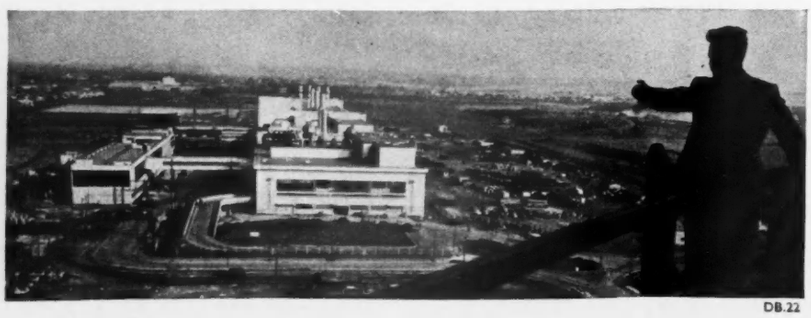

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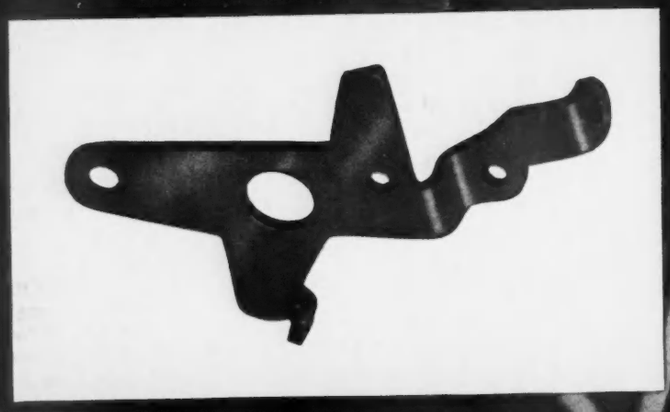


Electrical Aids in Industry *Data Sheet* **No. 8**

Light-Sensitive Cells

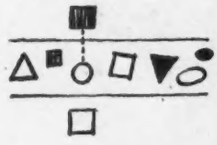
What are light-sensitive cells? They are devices which can sense and measure changes in the level of light or, in some cases, respond to the quality of light falling on them. There are various types of cell and each has its particular field of use. One of the best known is the photo-electric cell.

What can light-sensitive cells do? A change in the amount of light falling on the cell can cause a switch, relay or counter to operate. Alternatively, the direct indication of the light intensity can often allow some other factor to be determined and, if required, controlled. They are reliable and require little maintenance. Careful installation, as with all types of equipment, gives a good reward.

How can they be used? These cells have many applications in industry, for controlling processes, for inspection and measurement, for sorting material and for safety purposes:

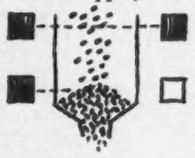
Counting

Where objects on a conveyor belt are too soft or light to operate a direct mechanical counting device, where they are too delicate or freshly painted to sustain physical contact or where the articles vary in size, a light-sensitive cell can be used. This counts the objects by interruption of an appropriately sited beam of light.



Hopper or Tank Level Control

Many forms of feed can be accurately controlled by light cells. One important one is for controlling the input to a hopper of fluid solids such as sand or peas. Here, two horizontal light beams are required: the upper, when interrupted, indicates that the hopper is full and stops the supply; the lower, when it ceases to be interrupted, indicates that the hopper is nearly empty and restarts the flow.



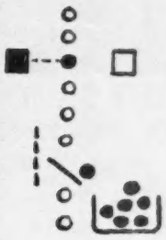
Package Content

The level of powder in packages can be checked with light cells. The cell is so positioned that when the powder is

up to the required level, the light reflected from the surface of the powder is picked up by the cell and causes the carton to be accepted. If not, it is rejected.

Colour Sorting

The quality of many articles can be gauged by their colour — seeds and nut kernels, for instance. The objects are fed into a tube by means of a vibrator pan and fall into the beams of three equally spaced light cells which scan them from all sides. If the object is acceptable it falls into a chute carrying it to one conveyor; if its colour is bad it is deflected as a reject.



Guillotine Guard

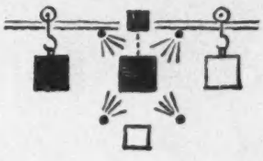
Light cells for guarding a guillotine or power press should be used only as a supplement to a mechanical guard or where the latter is impracticable. The interruption of a curtain of light by a hand stops the machine instantaneously.

Press Feeding

Where the rate of feed of strip metal must be suited to a varying speed of acceptance by a press, a loop of the strip is allowed to sag between the feed and the press. When the loop reaches a predetermined depth a light beam is interrupted and the slack is taken up.

Processing Objects on the Move

Many articles are processed while on a conveyor line. For instance, where articles are to be sprayed while on the conveyor, the paint saved by stopping the gun between articles will make the device worth while. The same principle applies in a bakery to the spraying of baking tins with fat.



Automatic Door Opening and Closing

Doors can be caused to open or close by the interruption of a beam of light. This has its uses in such cases as control of doors on a heating oven or for the passage of vehicles in a factory. This is effected by a light beam on the side from which the approach is made (in many cases, both). When the approach beam is interrupted it opens the door which closes again after a given time interval.

For further information, get in touch with your Electricity Board or write direct to the Electrical Development Association.

An excellent series of reference books are available (8/6, or 9/- post free) on electricity and productivity — "Higher Productivity" is an example. E.D.A. also have available on free loan a series of films on the industrial uses of electricity. Ask for a catalogue.

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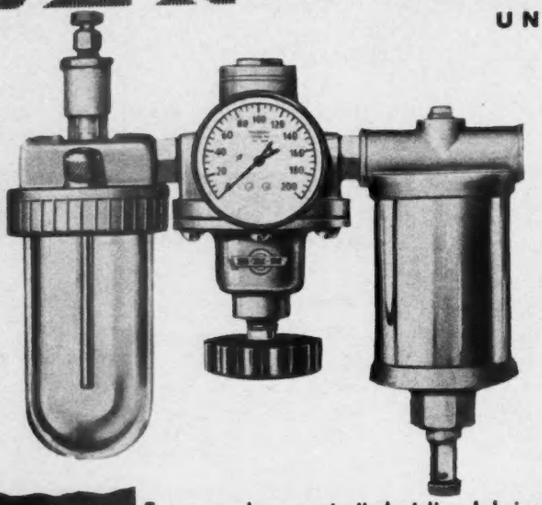

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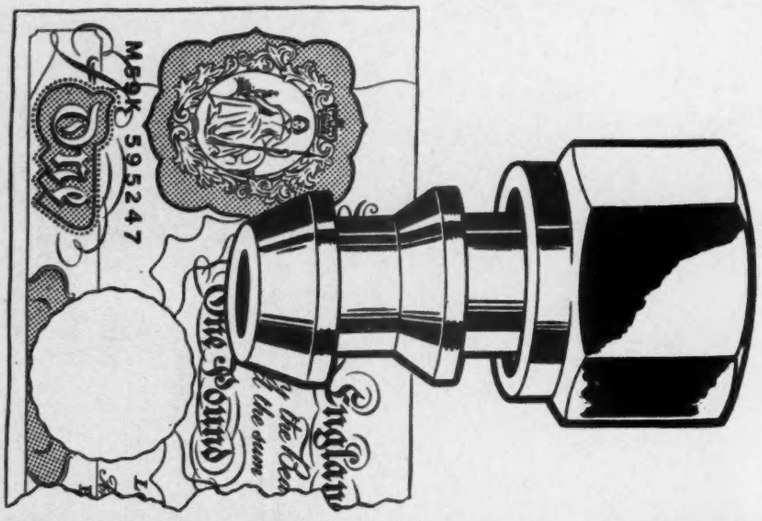

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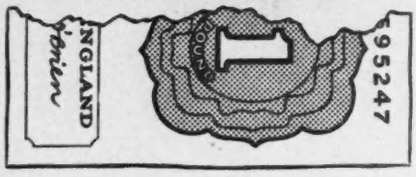

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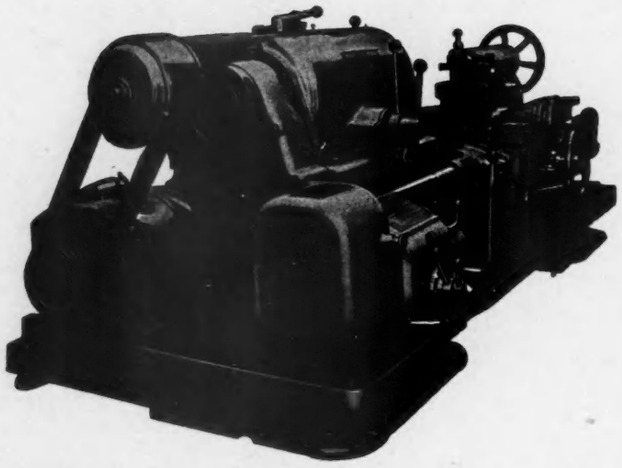

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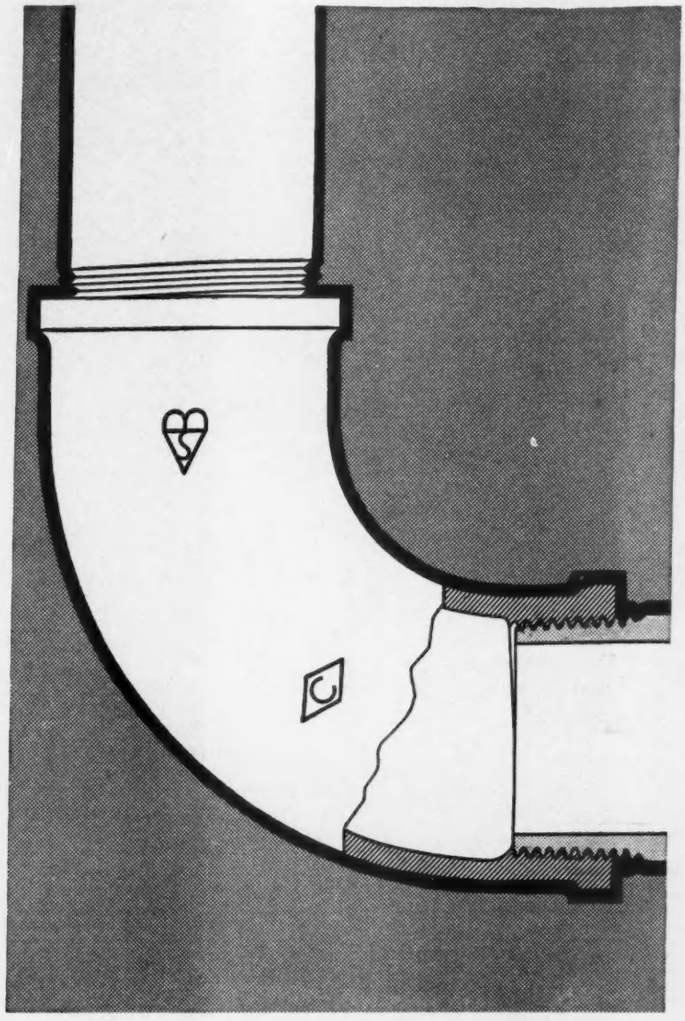

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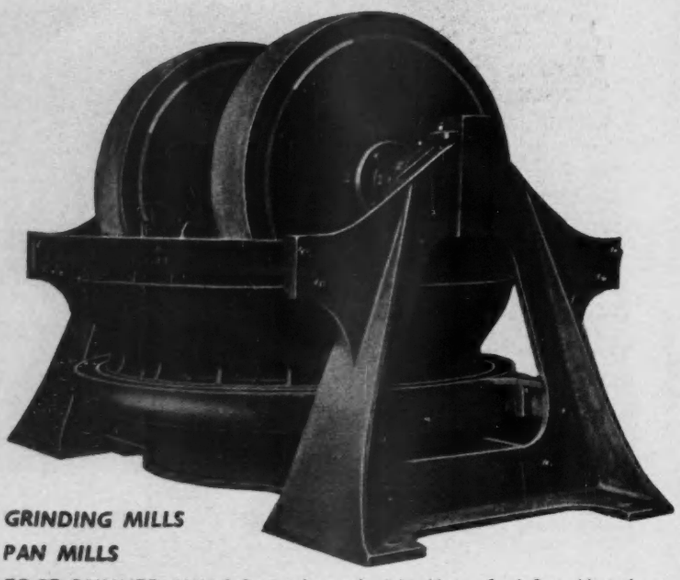

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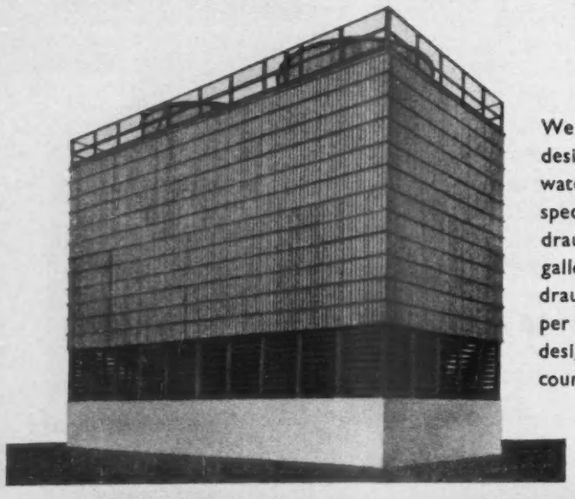

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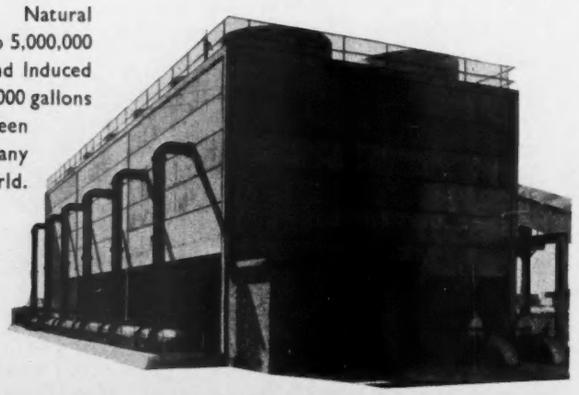

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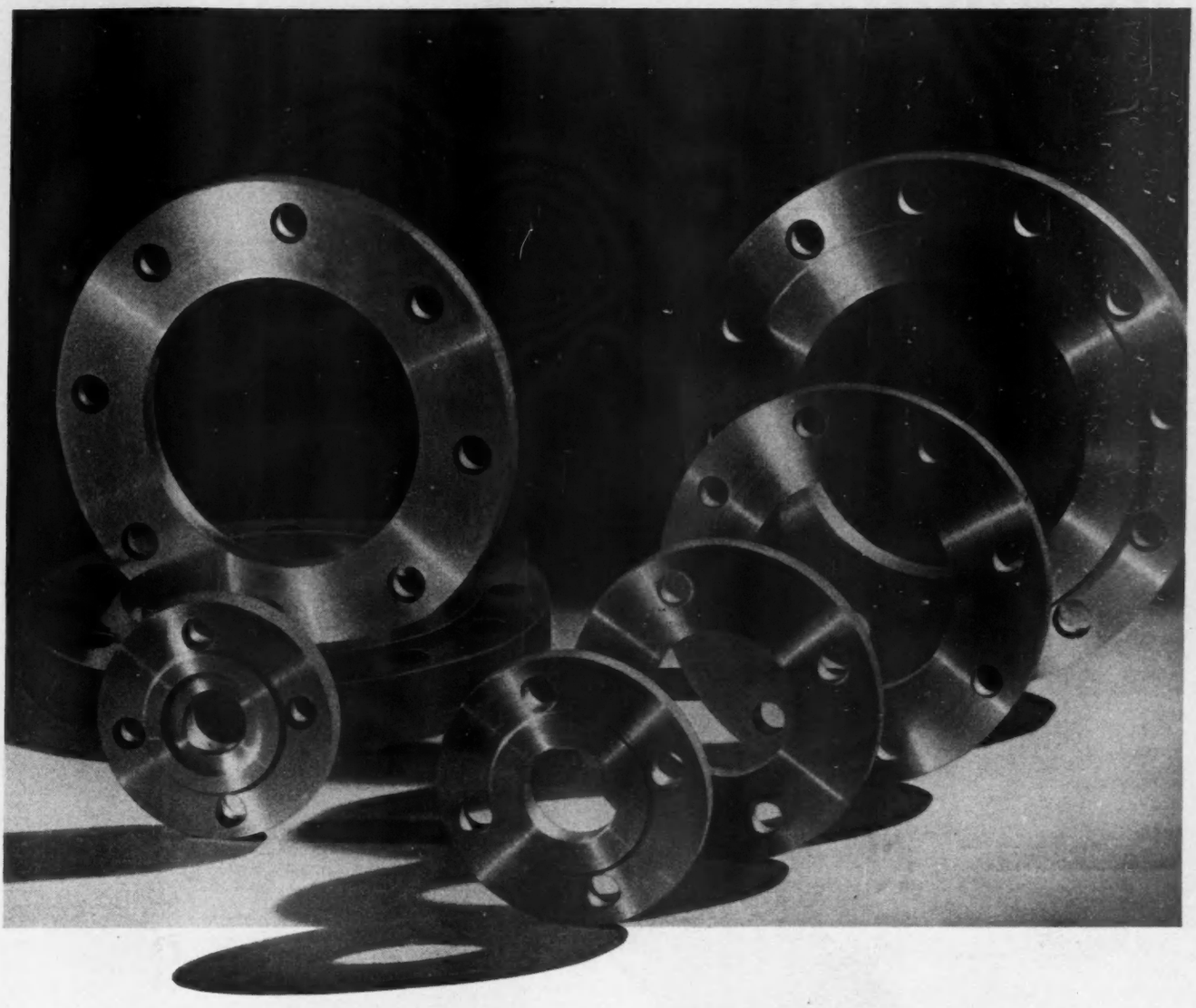

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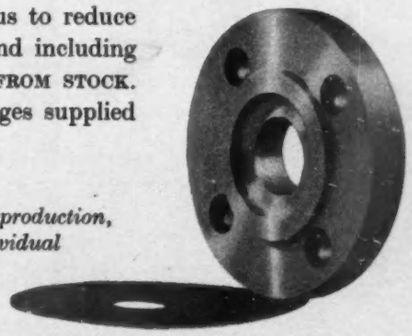

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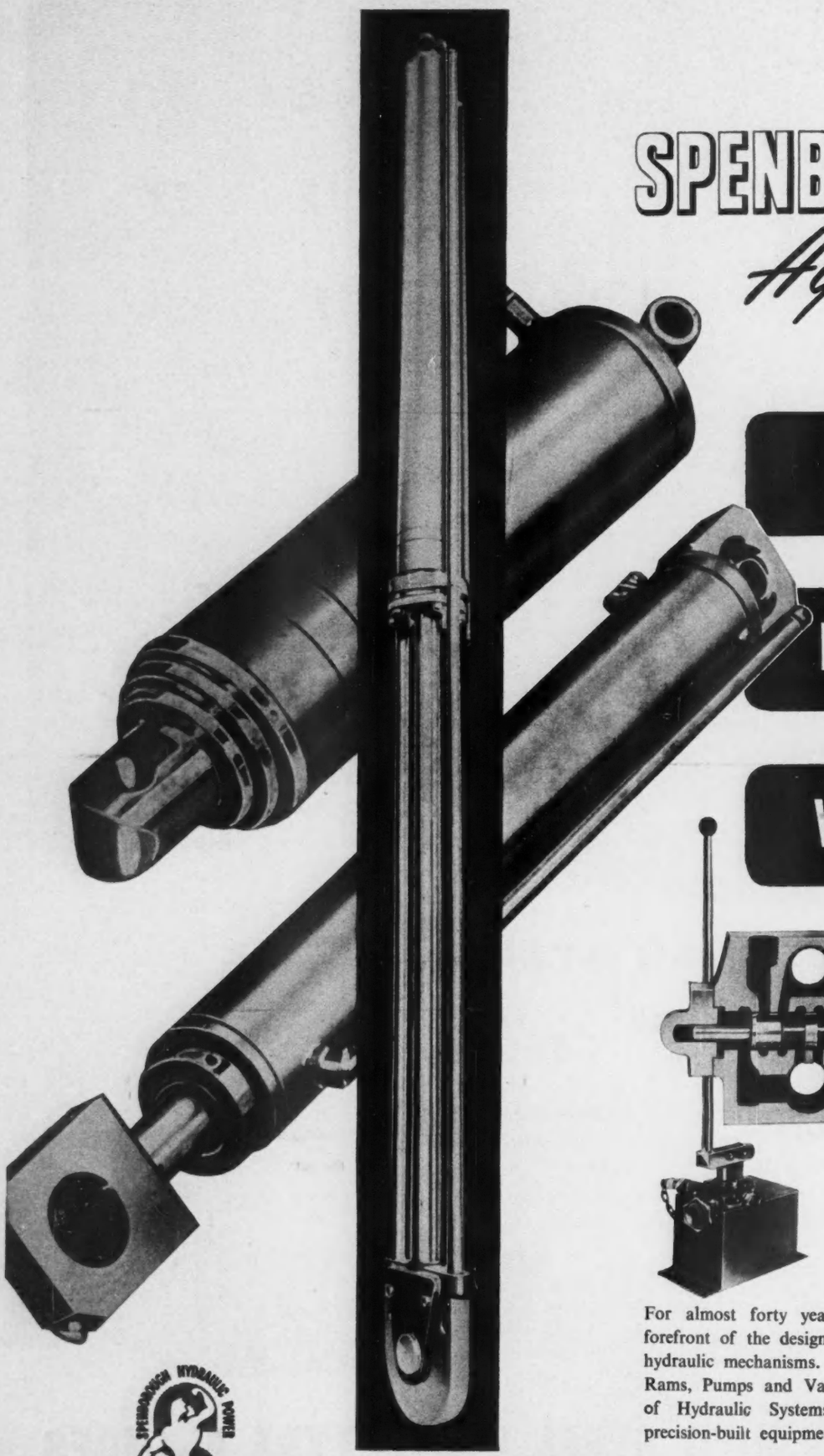

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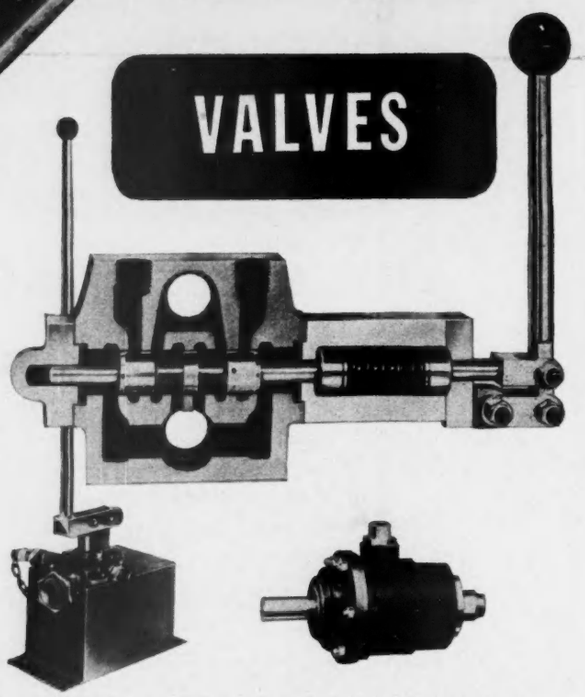

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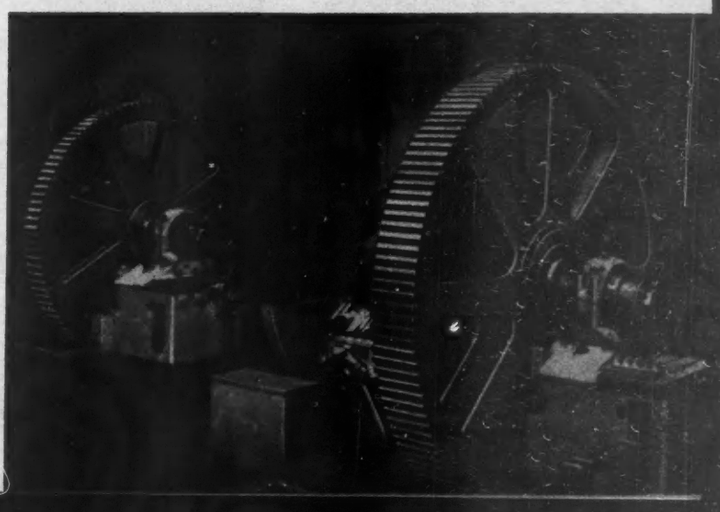

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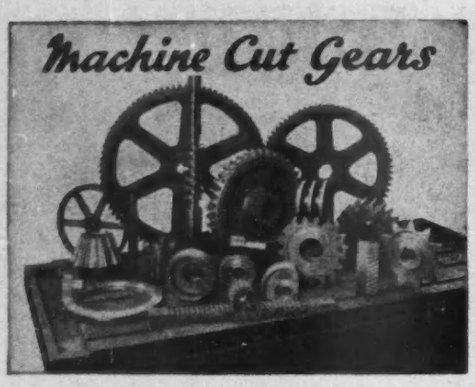

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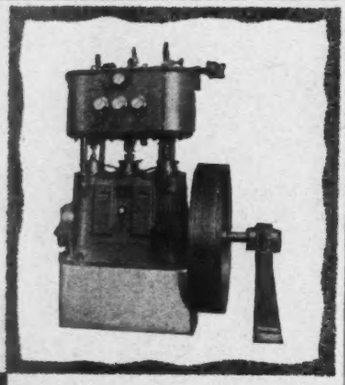

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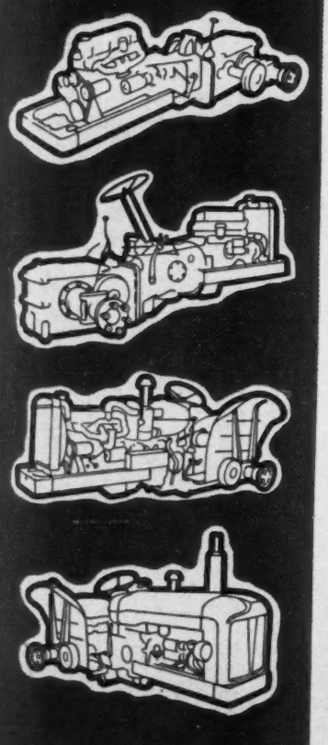

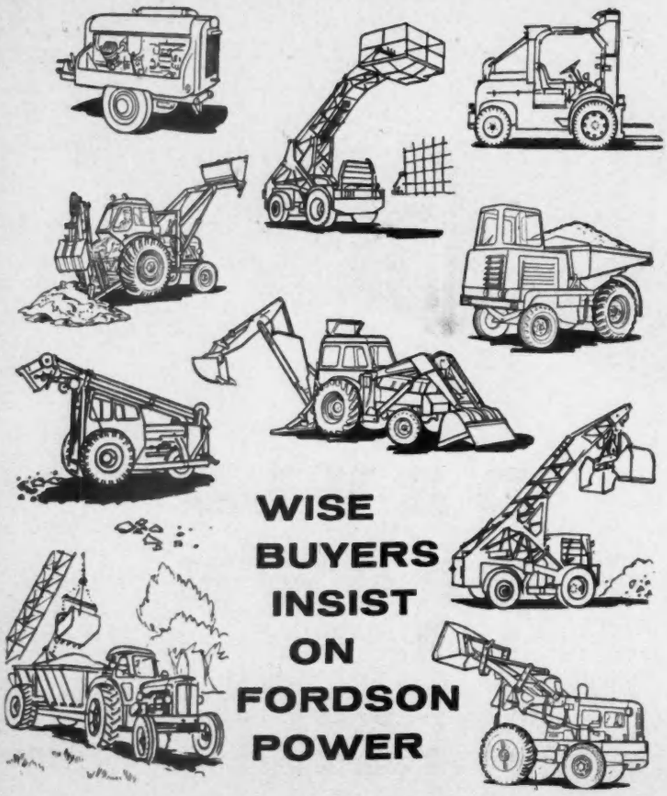

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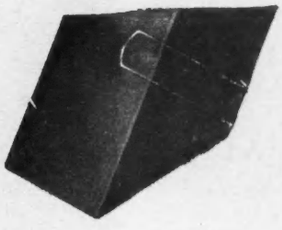

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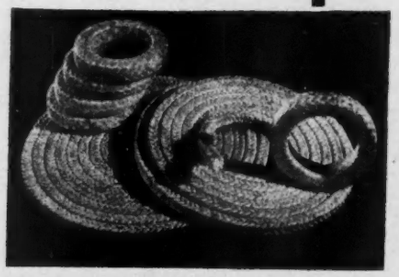

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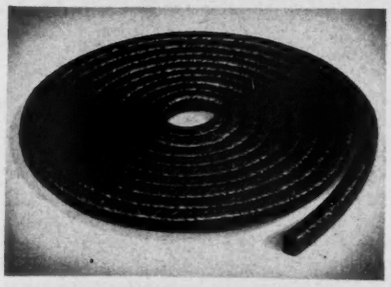

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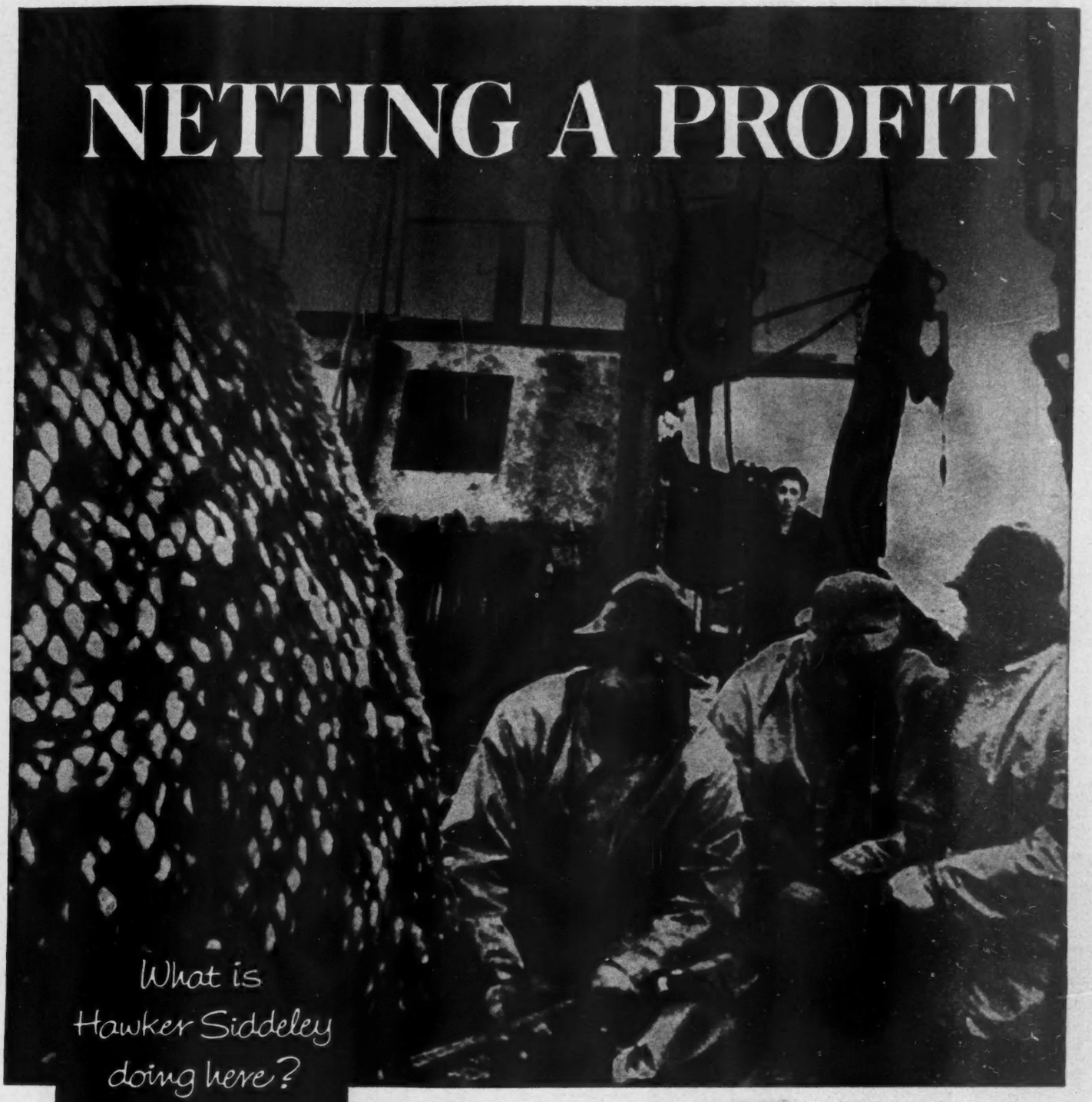

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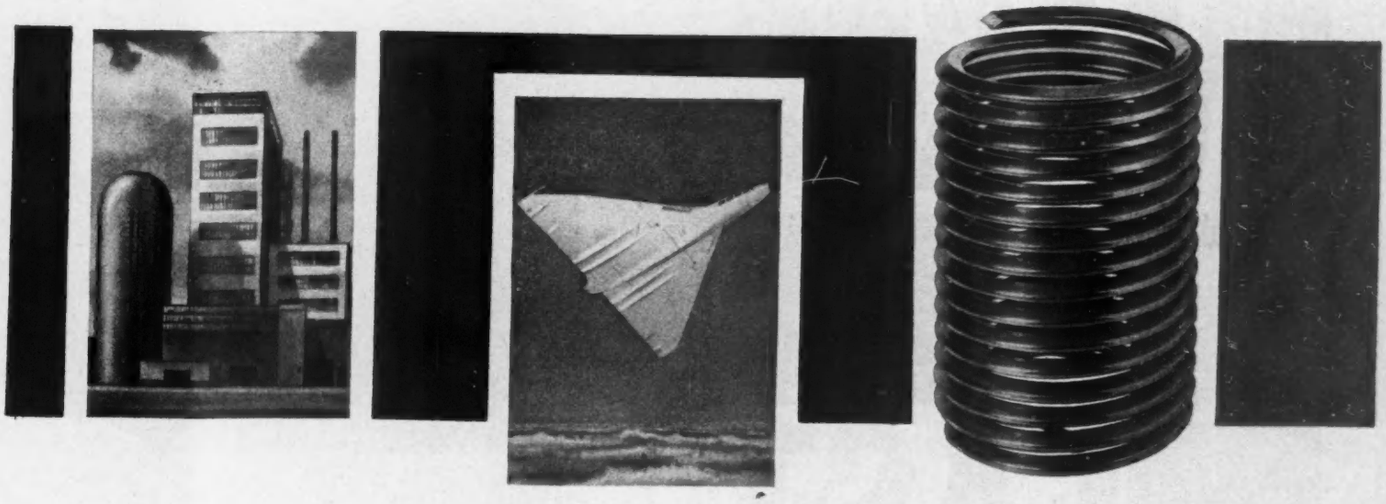

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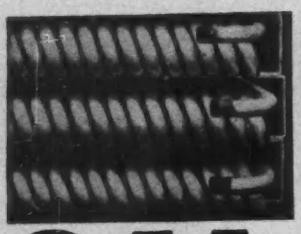

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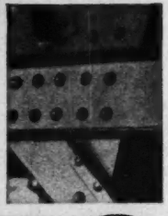

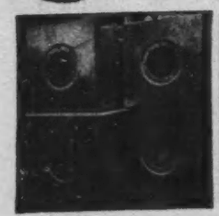

For further information write to
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34 Berkeley Square London W.1

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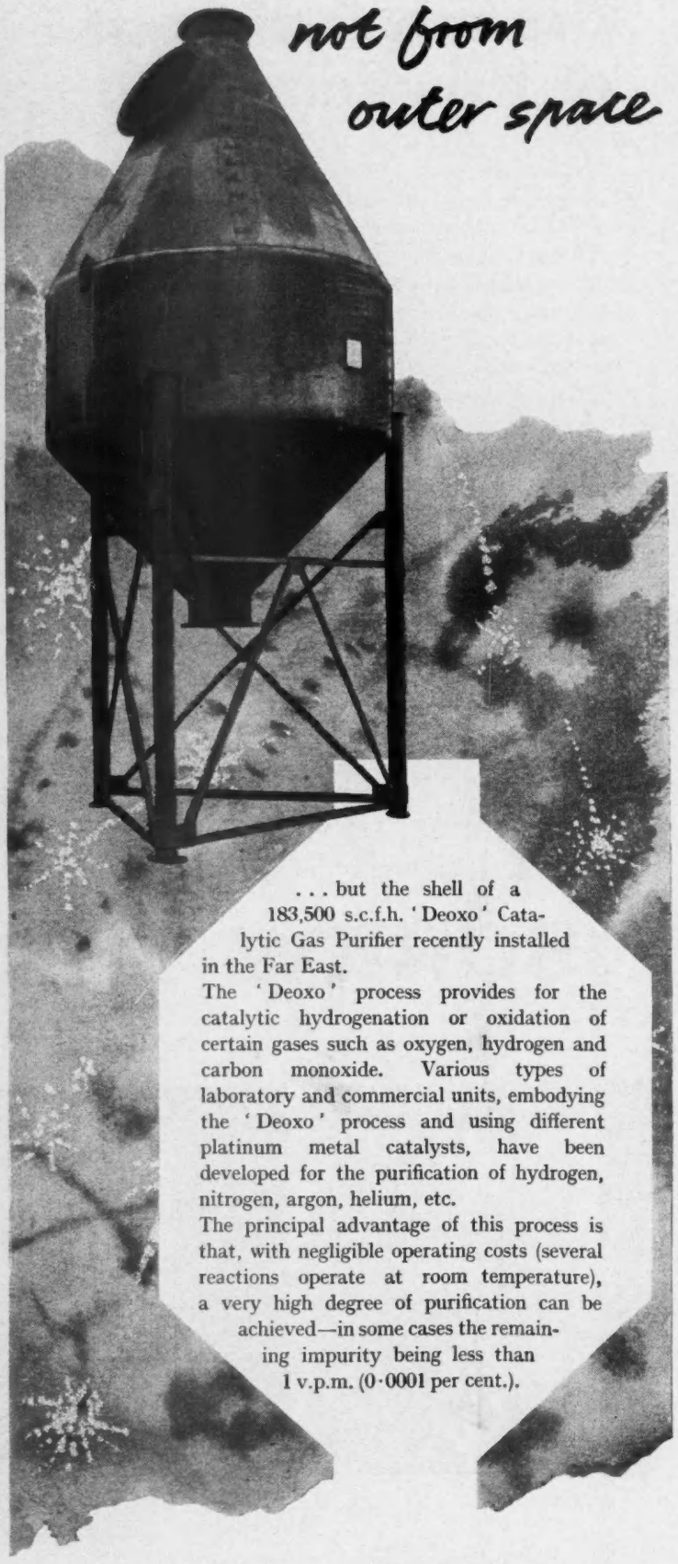

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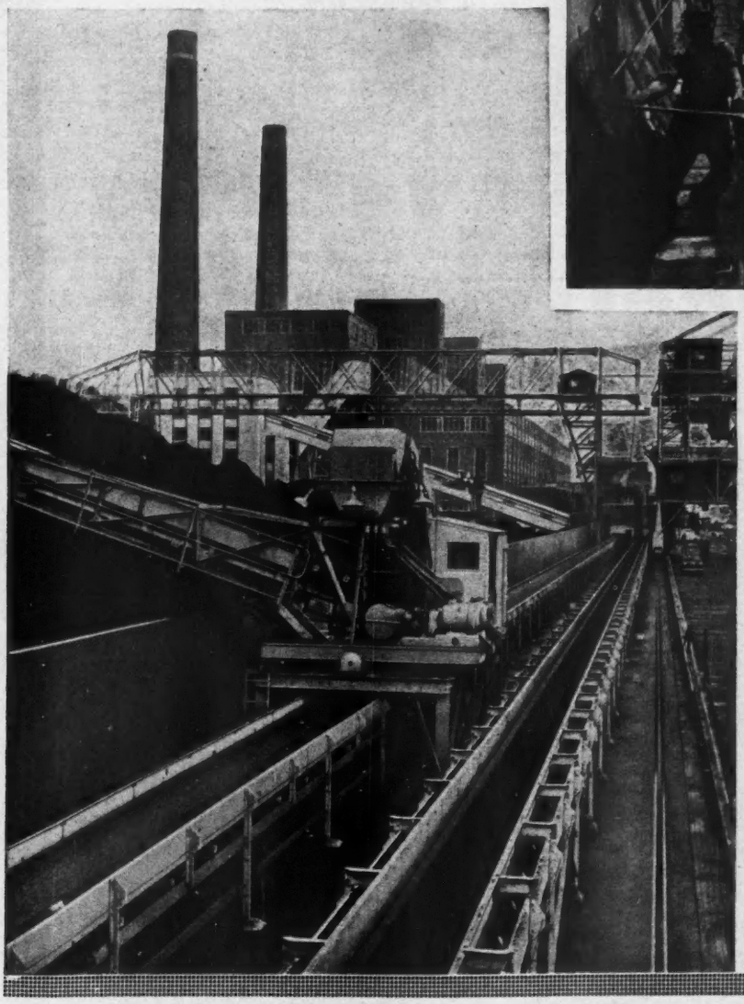

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Illustrated here are some of the 36" and 42" wide U.S. 'GIANT' belts which feed coal at 400 tons per hour from wharf-side to stock pile or boiler bunkers. Joints were vulcanised in situ by one of our mobile crews. They are shown here closing the press on number 3 conveyor.

Photographs by courtesy of Spencer (Melksham) Ltd. and the C.E.G.B.

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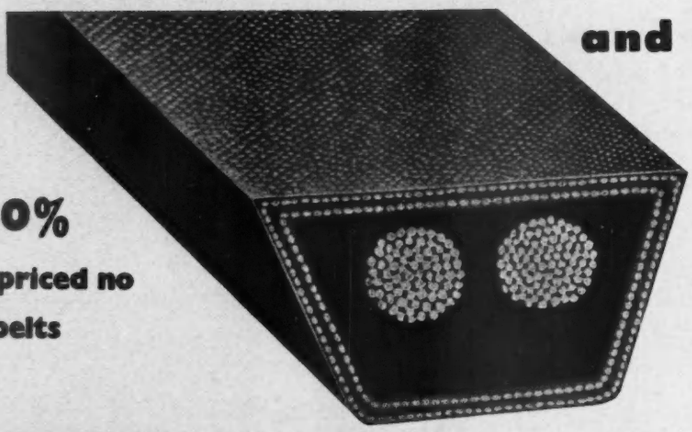
between this  and any other V-belt

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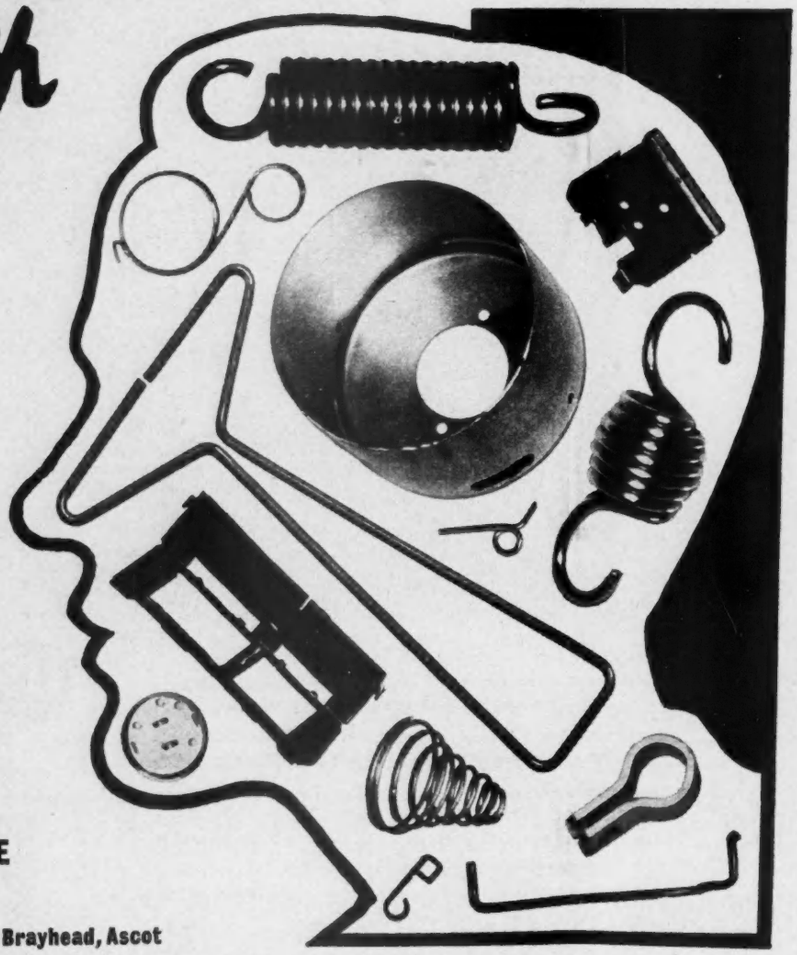

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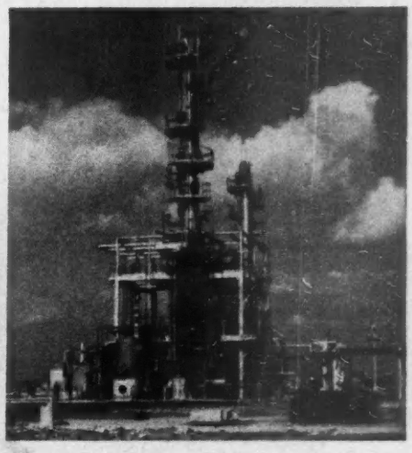

The two Columns erected at Coryton. One Column is 83′ 0″ overall height tested to 445 lbs. per sq. in. The other, 66′ 9″ overall height tested to 1,100 lbs. per sq. in.

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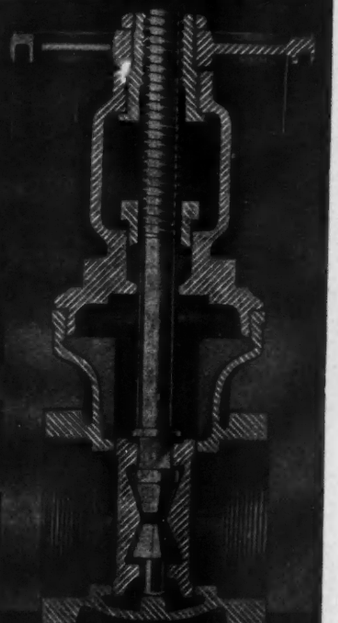

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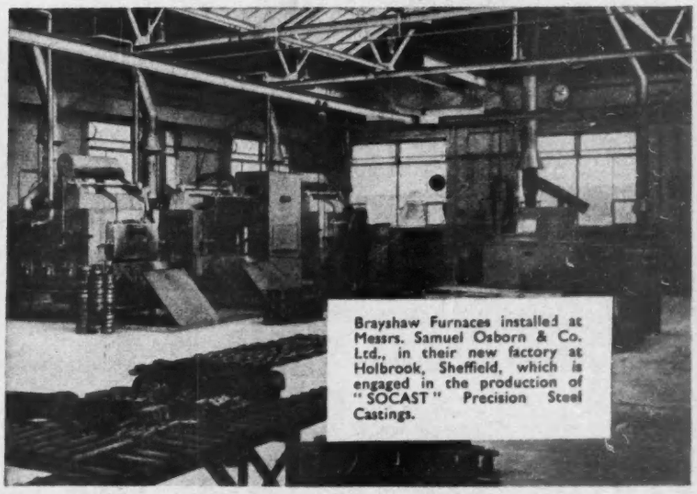

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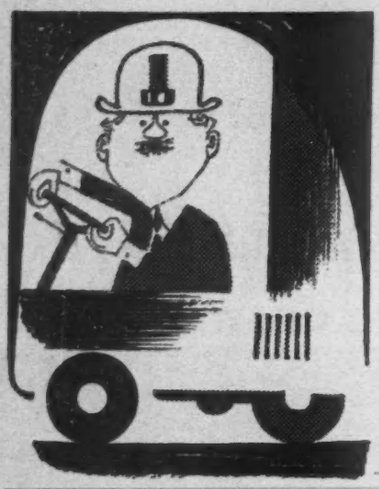

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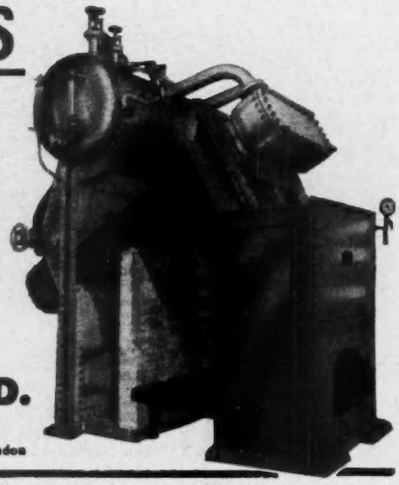

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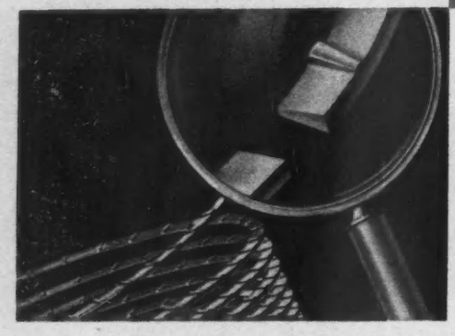

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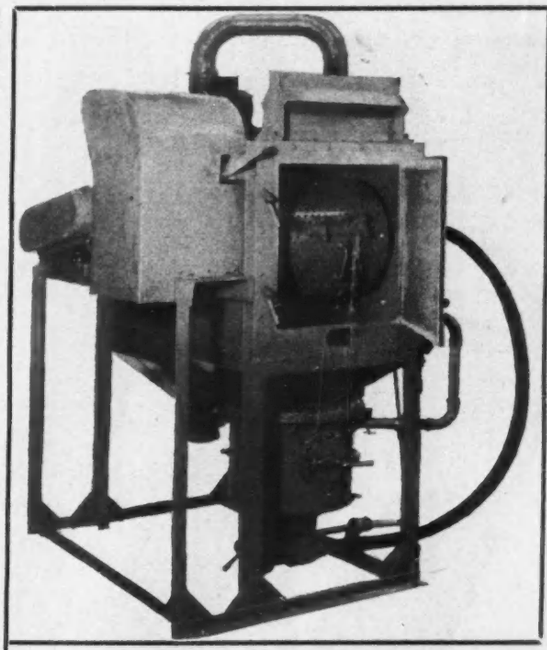

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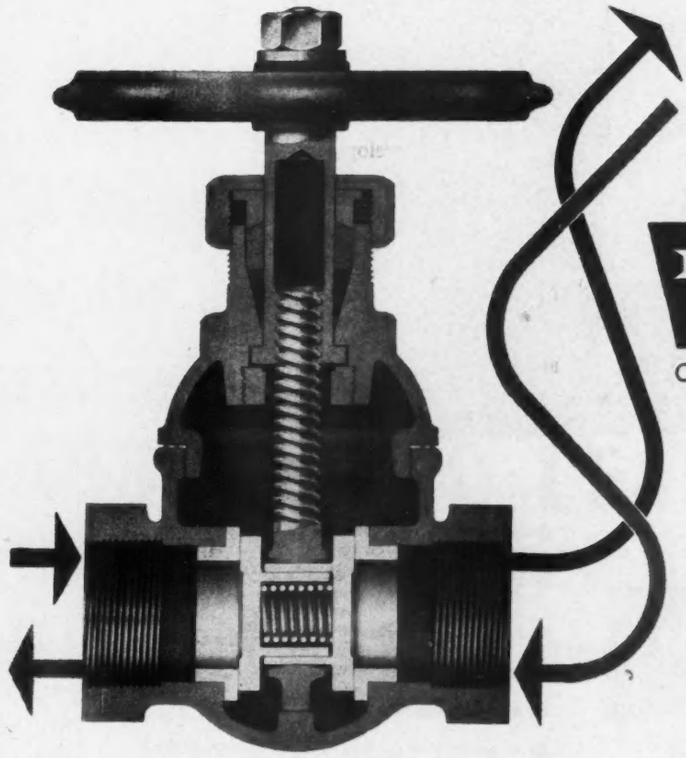

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